BELL TELEPHONE QUARTERLY

VOL. XVI OCTOBER, 1937 NO. 4

"TWX"—ITS GROWING IMPORTANCE TO THE NATION'S BUSINESS

THE PUBLIC HEALTH ASPECT OF THE TELEPHONE

THE ORIGIN AND DEVELOPMENT OF RADIO TELEPHONY

SOUTHWEST PASSAGE

THE INTERNATIONAL RADIO MEETING OF 1937

AMERICAN TELEPHONE & TELEGRAPH CO. • NEW YORK

An INDEX TO VOLUME XVI (1937) *of the*

BELL TELEPHONE QUARTERLY

may be obtained by addressing

INFORMATION DEPARTMENT
AMERICAN TELEPHONE AND TELEGRAPH CO.
195 Broadway, New York, N. Y.

BELL TELEPHONE QUARTERLY

A Medium of Suggestion and a Record of Progress

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VOL. XVI NO. 4

PUBLISHED QUARTERLY FOR THE BELL SYSTEM BY THE AMERICAN TELEPHONE AND TELEGRAPH COMPANY. SUBSCRIPTION, $1.50 PER YEAR, IN UNITED STATES; SINGLE COPIES, 50 CENTS

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THE BUSY HOURS AT THE TELETYPEWRITER EXCHANGE SWITCHBOARD REQUIRE AN OPERATOR AT EVERY POSITION IN ORDER TO HANDLE ALL REQUESTS FOR SERVICE WITHOUT DELAY.

"TWX"—Its Growing Importance to the Nation's Business

IN 1931 the Bell System offered a nationwide teletypewriter exchange service on a basis somewhat similar to telephone service. Today the directory for TWX, as this new service is called, lists more than 12,000 subscribers representing a good cross-section of modern financial and industrial business as well as governmental agencies. This growth has been rapid, substantial increases in stations being realized in practically every section of the country. It is true that the "private line" teletypewriter service of the Bell System with its rapid, direct, two way features has been available for more than 20 years, but this new service, which allows any subscriber to be connected with any other subscriber, greatly extends the benefits of this form of communication.

The inauguration of this new service involved many new problems; but the perfection of the teletypewriter, experience with switchboards for private line teletypewriter installations and the marked improvements in circuit stability and transmission characteristics, coupled with the general background of more than fifty years of experience in handling switching problems, gave assurance that such a service would be a success. The fact that the service was needed and has been satisfactory is demonstrated by the ever increasing group of users who have made this new communication service an integral part of their business. There has been developed and put into use a nationwide system of teletypewriter stations, circuits and switchboards with trained operating and maintenance personnel, which has no parallel. Switchboards are now in service in 160 centers with positions for 650 operators. These switchboards are interconnected by facilities providing 700,000 miles

of teletypewriter channels. The largest circuit group is between the switchboard in New York and the switchboard in Chicago with a total of 27 circuits. The longest circuit group is 3400 miles with 8 circuits between New York and Los Angeles. This vast network of circuits may be interconnected at the switchboards so that a connection may be built up on an instant's notice between any two subscribers.

The Teletypewriter Station

TWX subscribers are furnished a complete sending and receiving teletypewriter set. The sending is done from a keyboard very similar to that of a typewriter, and messages are received on a letter size page form. If the customer prefers, machines for typing on a continuous tape are available. For those having considerable traffic, a teletypewriter set is available which allows the message to be typed and stored in a perforated tape before the call is actually placed for the distant station. With this arrangement the messages may be prepared and checked in advance so that when the connection is established the transmission can go ahead at maximum speed (60 words per minute) without any interruption. For those who have need for typing on printed forms, an arrangement is provided for feeding the paper through the machine in accurately spaced steps by means of feed holes in the paper and sprocket pins on the paper platen. Also, as many as 6 or 7 carbon copies can be made when desired.

The subscriber's station is connected to a switchboard over a local loop as in the case of the telephone, and the trunk circuits of the system interconnect these switchboards. The subscriber calls an operator by operating a switch and the operator answers by typing "OPR" over the connecting loop. The subscriber then types the number of the called station, the operator proceeds to establish the connection, and the distant subscriber is called to his machine. This entire opera-

tion takes on the average about 1.3 minutes from the signal of the calling subscriber to the answer of the called subscriber.

In those cases where a subscriber desires to receive messages in his absence the station is arranged for unattended service. In this case the switchboard operator starts the subscriber's machine for the reception of a message and stops it when the transmission is completed. This feature is especially useful when there is a large difference in time between two points such as between the Atlantic and Pacific Coasts.

The charge to a subscriber for a connection depends on the distance between stations and the duration of communication as is the case with toll telephone service. For example, a 3 minute connection costs 30 cents for 50 miles, 90 cents for 500 miles and $2.20 for 2500 miles.

Switching the Written Word

Teletypewriter switchboards are much like telephone switchboards. They consist essentially of terminations for subscriber lines and intertoll trunks and the switching and communicating facilities used by the operator in conversing with the subscriber and with other operators and in interconnecting the line terminations. The one outstanding difference at once apparent is that in the case of the telephone the operator communicates by talking while in the TWX switchboards she communicates by typing. Various arrangements of these switching facilities have been made to meet the various conditions arising principally from the size of the subscriber group to be served. For example, the switchboard in New York has 1900 stations connected, 55 operating positions and 18 more positions being engineered. There are 330 toll lines terminated on this switchboard. This office has handled as many as 3700 outward calls in a single day.

One of the latest developments in TWX switching facilities is an automatic concentrator for mechanically switching a group of subscribers in one locality over a group of trunks to a manual

switchboard in another area. Such an automatic arrangement is installed at Norfolk, Virginia, connecting the TWX subscribers in that area over five trunks with the manual switchboard at Richmond, Virginia.

When the Norfolk subscriber turns on his machine to place a call, his loop is automatically connected to an idle trunk to Richmond and the operator there receives the calling signal. From that point on the call is handled in the usual manner. On incoming calls for Norfolk subscribers the Richmond operator plugs into an idle trunk to Norfolk, and types the called subscriber's number. This automatically connects the called station, the operator rings and the through connection is thereby established.

Communication Channels Totalling 700,000 Miles

The circuits which comprise the nationwide network of communication paths for the TWX service are the result of many years of development. Since they are the product of the same organization which has brought the telephone to its present stage of perfection in this country, much of the same technique is employed in both types of facilities. For example, the trunk lines of the TWX system are largely operated on telephone circuits by the carrier system. This allows the operation of 12 teletypewriter circuits at one time over a single telephone circuit. These carrier circuits and the methods of adjusting and maintaining them have been developed to a point where they can be interconnected at will and the transmission characteristics of the overall circuit accurately predicted. This flexibility and reliability is necessary in a switched service where each circuit must function perfectly whether it be made up of a single section of circuit or built up of several sections.

The fundamental plan on which the switching system is based involves Regional Centers and Routing Centers so interconnected with circuits that most connections can be estab-

lished without any intermediate switches and so that in no case will more than five trunks and four switches be involved in any connection between two stations. In all cases the transmission design must be such as to provide adequate margins of operation between two stations.

In transmitting the electrical impulses which represent the characters in the teletypewriter service, there is always a certain amount of deformation or distortion. This must be kept below certain limits in order for the transmission to be letter perfect. A repeater has been designed which is capable of receiving distorted signals and retransmitting perfect signals. This is called a regenerative repeater. Such repeaters are installed at strategic points so that they may be connected into any circuit where the overall makeup is such that the transmission might not be satisfactory without corrective measures. From a transmission standpoint, the regenerative repeater makes the long circuit equivalent to a shorter circuit.

Service Organization Behind the Lines

The fact has been stressed that TWX service has been made possible by the high degree of perfection which has been attained in the station apparatus, line circuit and switching facilities. In the operation of the TWX business, as previously mentioned, a large corps of operators is required to establish the connections. In many respects their work is much like that of the telephone operator and involves similar problems of recruiting, training and development. Mention should also be made of the maintenance organization which keeps all the intricate parts properly coordinated and in satisfactory working condition. Some of these maintenance groups are special for the teletypewriter service while others are engaged in telephone maintenance as well, but in all cases they have the broad background of training and experience which is necessary for the proper maintenance of modern communication facilities. For the stations there are installers, station repairmen and over-

hauling shops. For the switchboards there are the various groups of central office repairmen and power plant attendants and for the circuits there are repeater attendants, testboard men, linemen and repair gangs. To make their work accurate and effective the men are provided with tools, meters, testing sets, transmission measuring sets and trouble locators, all designed for the particular job to be done.

Building Up the TWX Connection

As an illustration of how a connection is built up for a TWX call, consider that a subscriber in New York is calling for a subscriber in Amarillo, Texas. The N. Y. subscriber turns on his machine.—The N. Y. operator plugs into the loop and types "OPR."—The subscriber types "AMAR 5."—The N. Y. operator determines from her rate and route guide that the route is through Dallas and that a repeater is required at Dallas.—She plugs in and rings on a Dallas trunk.—The Dallas operator answers and then the N. Y. operator types "AMAR REP."—The Dallas operator inserts the repeater, plugs in and rings on an Amarillo circuit.—When Amarillo answers, the number is passed by the N. Y. operator and Amarillo rings the subscriber. The N. Y. operator waits until he answers and then retires from the circuit.

Training of Customer's Attendants

The operation of the teletypewriter is quite similar to that of the ordinary typewriter and a competent typist can easily learn to operate it. However, in order to assure maximum proficiency in the operation of the service, the Telephone Companies of the Bell System offer to train customer attendants. At the convenience of the customers, this training is performed either on their own premises or in Telephone Company classrooms especially designed for this work. Adequate training usually takes from one to several days and covers operation of

Bakersfield, Cal.

Armour & Co meat pckrs 1427 Chester av BKFD 20
Bakersfield Garage & Auto Supply Co 1701 20th BKFD 25
Barnett-Lee Tractor Co 2120 Chester av BKFD 19
Boss Jack auto eqpmnt 1720 'K' BKFD 17
Chansler & Lyon Stores Inc auto supls 2415 Chester av BKFD 14
Hayward Lumber Co 1431 'H' BKFD 15
K E R N radio sta Elks bldg BKFD 21
§Mohawk Petroleum Co Rosedale Hway BKFD 18
Natl Supply Co of Calif oil well eqpmnt 3401 Chester av BKFD 16
Pacific Tel & Tel Co traf dept 1520 20th BKFD 9101
Pioneer Mercantile Co 1532 20th BKFD 12
Southern Auto Supply Co 1201 18th BKFD 23
Sunland Refining Corp 5th BKFD 22

Baltimore, Md.

Anchor Post Fence Co Eastern av & Kane BALT 98
Armour & Co pckrs Pratt & Howard BALT 181
Atlantic & Gulf Stevedores Inc Amer bldg BALT 391
Baker Watts & Co inv bnkrs U S F & G bldg BALT 395
Baltimore & Carolina Line Inc Pier 5 Pratt BALT 180
Baltimore Transfer Co Guilford av & Monument BALT 285
Bethlehem Steel Co Mercantile Trust bldg BALT 291
Brown Alex & Sons inv sec Balto & Calvert BALT 383
Bull A H & Co SS agts Pier 5 Pratt BALT 180
Cahn Frank B & Co bnkrs Equitable bldg BALT 390
Campbell Metal Window Corp Bush & Hamburg BALT 284
Chesapeake & Potomac Tel Co of Balt Cy 5 Light
§Genl Sales Mgr BALT 9103
Traf Training Dept BALT 9104
Chevrolet Motor Co 2122 Broening Hway BALT 199
113 W North av BALT 197
Murphy G M P & Co bank & ins stks Calvert bldg BALT 191
Obrecht P Fredk & Son feeds 423 W Pratt BALT 399
Owens Illinois Glass Co glass containers Standard Oil bldg BALT 87
Revere Copper & Brass Inc Baltimore div 1301 Wicomico BALT 388
Roosevelt SS Co Baltimore Trust bldg BALT 80
Schluderberg Wm-T J Kurdle Co pckrs 3800 E Baltimore BALT 188
Schouneman J Inc mfrs mens clothg 412 W Redwood BALT 280
Shirtcraft Co Horner Div Curtain av BALT 190
Sitnek Fuel Co Munsey bldg BALT 283
Smelkinson Bros Corp comm mchts 109 W Camden BALT 392
Standard Sanitary Mfg Co plbg fixts 5315 Holabird av BALT 294
Stein Bros & Boyce inv bnkrs 6SCalvert BALT 393
Steiner-Liberty Corp nightwr 416 Light BALT 86
Sun Papers Editorial Dept Sun sq BALT 282
Tri-City Freight Lines Inc 146 W West BALT 84
Truscon Steel Co 330 W 24th BALT 384
U S Industrial Alcohol Co Curtis Bay BALT 286
W B A L radio sta Lexington bldg BALT 92
W C A O radio sta 811 W Lanvale BALT 287
W F B R radio sta 7 St Paul BALT 189
Washburn Crosby Co Inc flour Whitaker bldg BALT 96
Western Elect Co Inc 2500 Broening Highway Point Breeze BALT 95
Westheimer & Co inv sec 211 E Redwood BALT 292
Whinney's Express 418 S Hanover BALT 290

Bangor, Me.

Eastern Mfg Co S Main Brewer BANG 13
Maine Broadcasting Co Studio 100 Main BANG 12
New England Tel & Tel Co dist hdqrs 59 Park BANG 9101
Pierce White & Drummond Inc invs 6 State BANG 14

§ Unattended Service Available
(see Alphabetical Directory page 2)

Teletypewriter Classified Directory

Abrasives
(See Machinery & Machine Parts)

Accountants

Utility Accountants & Tax Consultants
New York N Y N Y 1-2360

Acids

Hardesty W C Co Inc
Dover O DOVER O 29
New York N Y N Y 1-1884

Adhesives
(See Paints, Colors, Varnishes & Enamels)

Advertising Service

Albert Frank-Guenther Law Inc
Boston Mass BOS 35
Chicago Ill CGO 732
New York N Y N Y 1-1587
Philadelphia Pa PHLA 74
San Francisco Cal S F 128
Ayer N W & Son Inc
Chicago Ill CGO 592
Detroit Mich DET 276
New York N Y N Y 1-693
Philadelphia Pa PHLA 66

Advertising Service —Continued

Globe Advertising Agcy
Laredo Tex LAREDO TEX 65
Igelstroem John Co
Massillon O MSLN 8
New York N Y N Y 1-1754
Izzard Co
Seattle Wash SEAT 122
Katz Jos Co
Baltimore Md BALT 281
New York N Y N Y 1-986
Kudner Arthur Inc
Detroit Mich DET 485
New York N Y N Y 1-181
Livermore & Knight Co
Boston Mass BOS 59
New York N Y N Y 1-1448
Providence R I PROV 196
Lord & Thomas
§Los Angeles L A 590
§New York N Y N Y 1-1861
McCann-Erickson Inc
Chicago Ill CGO 1048
Cleveland O CLEV 185
Detroit Mich DET 294
New York N Y N Y 1-38
News Features Inc
New York N Y N Y 1-657
Petry Edward & Co
CGO 358

Advertising Service —Continued

Young & Rubicam Inc—Cont'd
§Los Angeles Cal L A 217
§New York N Y N Y 1-1549

Air Conditioning Equipment

York Ice Machy Corp
Philadelphia Pa PHLA 524
Washington D C WASH 188

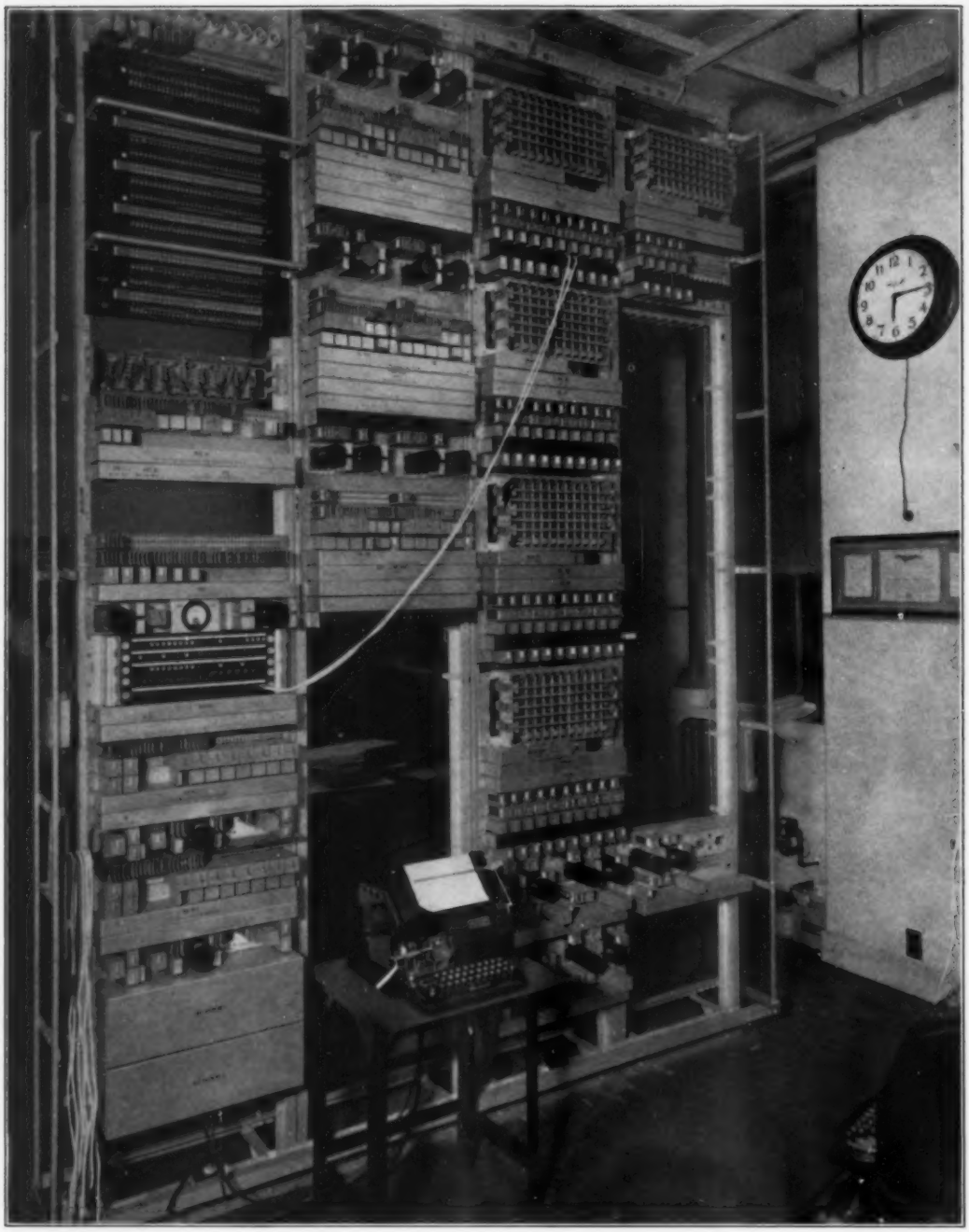
Air Transportation

Amer Airlines Inc
Camden N J CAMDEN N J 460
Chicago Ill CGO 308
Cincinnati O CIN 83
Cleveland O CLEV 81
Indianapolis Ind IPLS 398
Louisville Ky LSVL 185
New Haven Conn N HN 186
New York N Y N Y 1-1681
Newark N J NWRK 366
Philadelphia Pa PHLA 379
Port Columbus O COLS 92
Rochester N Y ROCH N Y 460
South Bend Ind S BD IND 20
Tucson Ariz TSN 3
Williamsville N Y WMSV 119
Pan Amer Airways Inc

PAGES FROM THE TWX DIRECTORY. THIS DIRECTORY IS NATIONAL IN SCOPE AND THE LISTINGS ARE A REPRESENTATIVE CROSS SECTION OF MODERN FINANCIAL, INDUSTRIAL AND GOVERNMENTAL UNITS. THE FIRST SECTION LISTS CUSTOMERS ALPHABETICALLY BY CITIES ALSO ALPHABETICALLY ARRANGED. THE SECOND SECTION LISTS CUSTOMERS BY LINES OF BUSINESS.

THE NO. 3A SWITCHBOARD, SUCH AS THIS ONE AT PITTSBURGH, PROVIDES CAPACITY OF AN ULTIMATE OF 1200 SUBSCRIBERS' LINES AND 240 INTERTOLL TRUNKS. THE MOUNTING OF THE TELETYPEWRITERS ON A SEPARATE TABLE BELOW THE SLOPING KEYSHELF ALLOWS THE SPACE ALLOTTED TO ANY ONE OPERATOR TO INCLUDE ANY NUMBER OF CORDS.

READY TO CONNECT ANY ONE OF 1900 SUBSCRIBERS IN GREATER NEW YORK WITH ANY OF 330 TOLL LINES, ALL OF WHICH ARE TERMINATED ON JACKS WITHIN HER REACH.



THIS AUTOMATIC CONCENTRATOR ACTS AS THE SWITCHING MEDIUM BETWEEN THE NORFOLK SUBSCRIBERS AND THE TRUNKS TO THE MANUAL SWITCHBOARD AT RICHMOND, VA.

the service, methods for setting up and organizing messages most effectively, etc.

How Business Uses TWX

That business firms are recognizing the benefits to be derived from the use of TWX service for meeting their written communication problems effectively is evidenced not only by the rapid growth in the number of subscribers but by an equally rapid expansion in the use made of the service by these subscribers. Teletypewriter connections are being established at the present time at a rate of well over five million per year.

Furthermore, the appeal of this new communication service is not confined to any particular line of business or size or type of concern. Numbered among its subscribers are the older concerns in well established lines of business and the newer concerns in more recent forms of business endeavor. It appeals in like manner to the larger business concerns with widespread interests as well as to the smaller businesses.

For the most part, especially in the beginning, TWX service has been used by subscribers primarily for communication between specific points, i.e., between various scattered units of the same firm or closely associated concerns, or between firms in different cities having a common interest or business relationship requiring more or less steady communication. In other words, the use of the service was principally on a "point-to-point" basis. This was a natural situation in that initially the relatively small number of subscribers made it somewhat difficult for individual concerns to visualize opportunities to use the service to other than the comparatively few fixed points with which they regularly did business. But as the number of subscribers grew in an ever increasing number of different lines of business, subscribers began to extend their range of calling beyond their regular "points." Use of the service was made to firms or points with whom they had need to communicate only occasionally but where speed and the two-way,

written features were important. Thus slowly and steadily the "random" use of the service is being built up.

This early growth of TWX service is somewhat analogous to the early development of telephone service. Initially the telephone "outlets" for the early telephone subscribers were principally to certain other particular individuals in their own local communities. As the number of telephone subscribers in each locality increased, the usage of the service made by individual subscribers increased accordingly, eventually growing beyond their own localities to others nearby or thousands of miles distant through the vast interconnection of these localities by toll circuits. An interesting difference in the early developments of these two services was that whereas telephone service expanded initially as a local service, TWX has grown principally as a toll service.

The fast, two-way, written record features of teletypewriter exchange service—its almost instantaneous speed of connection and transmission, the ability to "talk in writing" back and forth on the same connection and the identical typed copies at both ends—are the fundamental advantages which make it adaptable to the exacting requirements of today's business methods. Prompt handling of orders often necessitating the delivery of all orders the day received, intimate supervision of widespread activities, close coordination of production and sales, up-to-the-minute accurate reports of distant operations, the planning and organizing of each day's needs for maximum efficiency—are only a few of these exacting requirements. TWX service offers a new communication medium designed to meet these needs economically, quickly and with maximum assurance of accuracy.

Its unique and exclusive features provide a type of communication service not previously available. Its use is therefore not just a substitute for older forms of written or oral communication, although this may be the case in some instances. It opens new fields for new uses of fast communica-

tion in doing business. It often enables business to carry on functions or to do things better and more economically than was possible previously. The economy is derived sometimes in lower communication costs but more often in other ways—the less tangible but definite benefits resulting from speeding up operations, improving service to customers, smoothing out routines, saving time in shipments, permitting better control and regulation of production, shipping, traffic, distribution, administration, etc. For example, by speeding up the handling of orders between sales offices and production units by using TWX, many firms are achieving overall economy through more closely coordinated production and by reducing warehousing costs by shipping direct to customers. Also, the communication time saved makes it possible in many instances to increase substantially the number of orders shipped the same day, thus materially bettering competitive positions and, through improved service, to attract new business.

Some business firms have found that TWX service enables them to handle some things by fast written communication which could not be so handled in the past. In some cases in the past these things were handled orally, by telephone or personal visit. In other cases they were not done at all because there were no economical and satisfactory ways of handling them by fast communication means. For example, a large shoe concern is now teletyping orders on specially designed order forms from sales offices direct to plants. Thus, one teletyping of an order at a sales office will produce sufficient copies locally for its use, including invoice copies, customer acknowledgments, etc., and, at the same time, the necessary copies at the plants to enable production to start immediately. This new arrangement, in addition to effecting overall economies, will save one or more days over its former methods. Furthermore, all the people involved will have complete details regarding each order almost as soon as it is received

at the sales offices, and thus close supervision and coordinated attention can be given to all orders.

The limitations of this article do not permit a detailed discussion of the large number of uses which business concerns are effectively making of TWX service and the benefits being derived from such usages. However, in the following paragraphs, typical illustrations of the use made of certain of the more important features of the service are briefly highspotted.

Rapid Two-Way Written Communication

Of the many unique features of TWX service perhaps the one most appreciated by subscribers and extensively used is the ability to communicate back and forth—alternately but not simultaneously—on the same connection. One common application of this feature is to carry on a written communication of the question and answer type in which the reply to a specific request is given and discussed on the same connection. This may involve any of the usual details of the every day business transaction—"How soon can we ship this order?" "What price can we quote on carload lots?" "When will production of such and such an order start?" "Should we hold for further credit check?" etc.

In analyzing the value of the two-way feature, consideration might be given to its usefulness in meeting one of the simpler requirements for fast written communication found in almost any business—the transmission of orders to production points, warehouses or sources of supply. Although the actual transmission of orders might be handled in many cases by fast one-way communication service, there is frequently the need for an immediate or subsequent discussion between office and plant regarding individual orders. The plant, for example, may have recently discontinued manfacture of a specific pattern or size and may wish to obtain approval to substitute or to get suggestions from the sales office. Due to low stock, it may be impracticable for the plant to meet the shipping dates re-

quested and assurance is desired that delayed shipments would be acceptable, or that new dates be set up. Again, more precise manufacturing instructions, engineering specifications, shipping information, etc., may be needed by the plant prior to completing the order. These typical factors tend to make

```
SUPERIOR PAPER CO  CGO
PEORIA CALLING   REF LISKA INQUIRY ON G ROD AND BLUE FOLIO 16

OUR STOCK IS OK    GRAIN 22 INCH WAY
SHALL WE SHIP
GO
OK SHIP    IS IT MILL 16
GA
MIN PLS
NO NOT MIDWEST
GO
WE DO NOT WANT A WATERMARKED SHEET     THAT IS WHY WE ASKED
GA
THIS ISNT WATERMARKED
OK SHIP
END
END
```

Illustrating the Value of the Two-Way Feature of TWX in Reaching Quick Decisions. Symbols "GO" and "GA" are Intermediate Closures Indicating Other Party May Type.

the problem of adequate and prompt order handling more difficult unless the two-way interexchange of information can be handled quickly. Furthermore, customers frequently inquire at sales offices as to the status of orders, the probable shipping dates, and other specific queries regarding orders already in process. Many businesses feel that the two-way

feature of TWX service is necessary in order to obtain this information from the production and shipping points as soon as practicable, and is important to them in maintaining good customer service and good-will.

Other businesses find that the two-way feature of TWX helps them in their every day purchasing problems, especially when rush items or special supplies must be obtained quickly. Frequently on the one TWX connection orders can be placed and prices and deliveries agreed to—the whole transaction completed. Furthermore, they can use it to "shop around" for best prices and deliveries, particularly important when the usual sources do not have the desired supplies or can not ship them in time.

For handling credit matters, many TWX users find the two-way feature especially helpful since it permits answers to credit inquiries on the same connection, affords ample opportunity to discuss individual credit matters in greater detail or to suggest special action or treatment, and enables misunderstandings and misinterpretations to be discussed and straightened out at once. An interesting example of this usage is that made by branch retail stores of a large mail order firm to obtain the amounts of credit which can be extended on certain accounts. This firm is attempting to build up its business by offering a special purchasing arrangement on a time payment basis. Precautionary measures are, however, necessary to assure adequate protection against losses, due to poor risks, large outstanding accounts, etc. Out-of-town branches refer specially large orders to a centralized credit department at the main office for credit approval. The latter point maintains extensive records of all customer accounts and has TWX machines located in close proximity to them. In practically all cases they are able to give replies on the same connection, often within a minute or so. Delays in turning over merchandise to customers are thereby minimized and business which otherwise might be lost is saved.

General business firms find the two-way feature equally valuable for discussing matters of administrative policy with distant units, for giving or receiving comments on sales and other special reports, for obtaining quotations and bids,—for almost any of the myriad of problems which arise daily in the operation of business. Specialized businesses find it helpful also,

JOHNSON CARTAGE DECATUR MAY 26
BLOOMINGTON CALLING

WILL YOU HAVE A TRUCK COME THRU HERE. WE HAVE A LITTLE FREIGHT LEFT OVER FOR CHICAGO AND SOME OF IT IS PERISHABLE. GA

I WILL NOT HAVE ANY ROOM LEFT AND WILL HAVE FREIGHT LEFT OVER. IF WE CAN SCRAPE UP A TRUCK WE WILL HAVE HIM COME THRU. GA

123 IS COMING THERE FROM SPRINGFIELD. WILL HE HAVE ANY ROOM FOR US. HE HAS FRT FOR YOU. GA

IF HE HAS FREIGHT FOR US WE WILL SEND HIM THRU TO TAKE CARE OF YOU. WE WILL NOT HAVE TO LOAD ANYTHING ON HIM THAT WE KNOW OF.
END

OK THANKS END

QUICK EXCHANGE OF INFORMATION PROMOTES GREATER EFFICIENCY.

e.g.—airlines, railroads, motor transportation and steamship lines use it regularly for dispatching, arranging for freight and cargo space, making reservations, assigning relief schedules and locating delayed shipments; radio companies use it for coordinating programs and arranging for special broadcasts and pickups; newspapers and news agencies use it for getting the latest flashes on political, financial or general news; banks use it for arranging for transfers of funds; and law enforcement

agencies for exchanging information on law violations and criminals.

J D CARPENTER CO CALLING PEORIA 6-30-36

1. REFER DWG. F-6196 - WHY CANT SCOTT MACHINE SURFACES DOWN TO BE PERFECTLY FLUSH WITH TOPS OF PYRAMIDS WHICH YOU SPECIFY 3/4" THICK. WITH THEIR PAPER THEY MUST AVOID ANY RECESS.
2. WATKINS CLAIM 20" LEAD PRICE MUCH HIGHER THAN EUROPEAN COMPETITION. PLS ADVISE DID YOU FIGURE THIS SPECIAL BEING AN EXPORT JOB. ALSO HAVE YOU PATTERNS FOR 20". IF NOT WOULD IT NOT BE CHEAPER TO FIGURE 18".
3. LITTLE WANT PRICE 150 SCREWS FOR BRONZE MACHINES LIKE FURNISHED LAST ORDER BUT MADE OF SPECIAL METAL MANUFACTURED BY NASH. GUSTAFSON.

END

1. THEY CAN MACHINE THESE DOWN JUST AS THIN AS THEY WANT TO. BUT GENERALLY THE SURFACE OF THE PYRAMIDS IS NOT PARALLEL TO THE PACKING SURFACE - IN OTHER WORDS YOU WOULD RUN INTO THE PYRAMIDS ON ONE CORNER AND NOT TOUCH THEM ON ANOTHER. WE ALWAYS MAKE AN ALLOWANCE FOR THIS.
2. YES, WE FIGURED THIS SPECIAL. WE ALSO HAVE 20" PATTERN AND FIND IT FIGURES MORE EXPENSIVE IN THE 18".
3. WILL WIRE AS SOON AS CAN GET PRICES.

END

1. BRYAN TELEPHONED AND RAISED THE POINT BECAUSE SOME OTHER MACHINES AT THEIR REFINERY WITH WHICH THEY CHECKED HAD OUTER SURFACES PERFECTLY FLUSH AND UNIFORM THRUOUT. I WILL THEREFORE TELL THEM THEY CAN MACHINE DOWN TO 3/4" OR TO THE HIGHEST PYRAMIDS. DO YOU AGREE. END

1. YES END

Direct, Two-Way TWX Connections Help Smooth Out Production Problems.

It has been previously pointed out that the small as well as the large business derives desirable benefits from the use of TWX service. The communication problems, however, of the

TELEPHONE COMPANY INSTRUCTORS ARE PROVIDED FOR ASSISTING TELETYPEWRITER ATTENDANTS TO BECOME PROFICIENT IN THE HANDLING OF TWX COMMUNICATIONS. WELL EQUIPPED TRAINING BUREAUS ARE AVAILABLE AT THE CONVENIENCE OF THE ATTENDANTS FOR PRACTICE AND INSTRUCTION.

A Typical TWX Customer's Station Equipped for Direct Keyboard Page Sending and Receiving. The Attendant Has at Her Right the Controls for Signalling the TWX Central Office Operator.

The Home Office of a Nationwide Produce Marketing Agency Uses Automatic Transmission for Daily Conference Connections to Brokers and Branch Offices in Distant Cities. The Telephone, Conveniently Located, Enables Last Minute Quotations and Market News to Be Gathered Locally and Sent on These Connections.

Some Large Concerns Have Need for a Group of Machines in Their "Key" Communication Centers to Handle Their Teletypewriter Traffic to Widespread Suppliers, Factories, Branch Offices, Customers, etc. (above) As Many as 1600 Messages in a Single Day, Some of Them Pages in Length, Are Handled in This Eastern Office of a Large Manufacturer. (below) A Steel Concern Keeps Up a Continuous Flow of Communications to Its Widely Scattered Units Through This Centralized Teletypewriter Communication Room.

HUNDREDS OF INVESTMENT HOUSES, LIKE THE ONE ILLUSTRATED ABOVE, FIND TWX A NECESSITY IN THE EFFICIENT HANDLING OF THEIR TRADING OPERATIONS.

TYPICAL OF THE MANY BUSINESS OFFICES WHICH USE THE DIRECT, TWO-WAY CONTACT OF TWX FOR TRANSMITTING ORDERS, REPORTS, INSTRUCTIONS, ETC., TO DISTANT PLANTS AND OFFICES.

larger industrial concerns, particularly where operations are "spread out" over a wider territory, are often apt to be much more complex and require careful study and planning to determine the most satisfactory and economical methods of employing the service. The activity of each individual department or unit must be properly coordinated with that of each other department or unit so that maximum efficiency may be realized. Lack of speed or carelessness in adequately coordinating information between departments may mean costly delays, less efficient production, late shipments, lost orders, etc. Cooperative reviews by Bell System representatives with business concerns to determine how the handling of their communication problems can be improved, often develop the need for better organization, orderliness and control. It has also been demonstrated that adequate organization and supervision of communications is often as important to the smooth functioning of a concern as that of other operations of the business.

Many of these large concerns have found that the two-way feature of TWX service has been the "key" to their ability to organize their communications efficiently. Their two-way usage is not wholly the immediate "question and answer" form described earlier but the interchange during each connection of all communications on hand at each point. These communications may involve any or all departments of the business and, during any one connection, may be sometimes unrelated. Requests for information sent on one connection may be answered on the next or succeeding connections. For example, during one connection between an office and a plant, the office may send details of all new orders received and the plant send back shipping information on all orders shipped since the last connection. This form of two-way usage is particularly effective where there are fairly large volumes of routine communications not requiring instant speed. To avoid "holding up" urgent communications, additional "in-between" connections are es-

tablished or those communications are sent by other means—telephone or telegraph.

Effective communication supervision and organization of course requires efficient office management. For example, the setting up of a suitably organized plan for control of communications generally includes establishing a centralized point for concentrating communications where the sending and receiving of messages may be controlled, setting up methods of collecting and distributing individual communications from this central communication point to the various departments, units and individuals involved and coordinating this distribution with shipping schedules, office routines, plant production, etc. It also frequently involves working out definite schedules of connections to specific points at those times during the day when the volume of communications between these points and their nature and urgency warrant so that all communications may be sent, received, distributed or relayed with clocklike precision.

Business firms report that this better organization has not only added to the volume of business matters handled by fast communication but has also, among other things, facilitated inquiry and reply, speeded up internal administration, simplified and expedited order distribution, and enabled closer supervision of shipping, production, purchasing, etc. These advantages arise from the fact that under organized communication plans all departments know when to expect communications and can plan their actions accordingly. Communications thus become not an adjunct to the operations of the business but are made an integral part of them. These firms also report that when intelligently worked out, organized plans of usage permit ready supervision of the flow and direction of all communications and thus assure getting the maximum value for the communication dollar spent.

Communicating Simultaneously with Several Points

Many business firms have need, either regularly or occasionally, to communicate with a number of points at one time. This may be, for example, to get information or instructions to several points quickly and accurately, to receive comments or reports from all points promptly, or to permit these points as a group to exchange ideas and views on important matters. Service arrangements which permit the simultaneous connection of three or more stations are available to accomplish this. This feature of TWX service is known as "conference service."

A large copper and brass company with headquarters in the east and sales branches throughout the country uses conference connections as occasions arise to get important price changes to all points quickly. The speed of this service feature is particularly helpful to them in protecting against further orders at the former prices and the simultaneous coverage assures that the new prices will become effective at all points at the same time.

Another excellent illustration of the value of this feature in meeting business requirements of this type is the use made by a large marketing agency that distributes throughout the country a general line of fresh fruits and vegetables for the account of growers. Several times daily the home office uses TWX conference calls to furnish about 35 brokers and branch offices last minute reports on quotations and market data. This large and fast coverage gives better assurance that quotations will reach markets where prices and demand are greatest. It provides the brokers and branch offices with a greater amount of produce to sell and, through furnishing them with firm quotations, enables them to complete transactions with no further need for confirmation. This latter factor alone saves them several hours daily.

One of the most interesting uses of TWX conference service is that made by the Federal Bureau of Investigation of the

U. S. Department of Justice. The headquarters in Washington may wish to disseminate quickly to all field offices throughout the country special information or instructions regarding a new administrative routine, a robbery, a kidnapping, a "manhunt" or any one of hundreds of law enforcement activities

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V  OPR  CONF 812  OKV  READY ON CONFERENCE 812  OK

8.13 AM EST ANCE PITB CALLING 9-1-37

ALL QTNS SUBJ TO CONFMN FOB SHPG PT UNLESS OTHERWISE SPECIFIED


LOS ANGELES - CITRUS
USUALLY CAN DEPEND HIGHER PRICES VALS IMMED FOLLOWING LABOR DAY WHEN
VACATIONERS RETURN SCHOOLS REOPEN LOCAL PRODUCTS BEG CLEANUP  WIDE RANGE
PRICES ACCORDING QUAL INDIVIDUAL CARS

SUBJ UNSOLD  5.00-150S LGR  5.35-176/288S  MIMIC  .15 HIGHER KANSAS CITY
  MERCY   5.85 SAME DISCOUNTS ROLLING CGO  MORAL  MOUTH

FINISHED VAL SHPMTS THIS YR WITH LAST FRUIT SHIPT YEST AT BOTH POMONA
GLENDORA  EXPECT START SHPG BLUEBOW RUBIDOUX PACKS FROM RIVERSIDE
LAST THIS WK


TOKAYS
FLORIN SHIPT 29TH  910 GOOSE 28-LB NET DISPLAY LUGS 1.05 PFE 70882
IMMED SHIPT 1.00

MODESTO SHPMT 30TH GOOSE MIXT  5 SDLS .722  62 TOKS .95  843 RED MALS
.85  RD 21953

IMMED SHPMT REEDLEY GIRDLED SDLS 28-LB NET DISPLAY LUGS CELLOPHANE
CURTAIN CUSHION PACK GOOSE  .722

BARTS
LAKE CO COLD STGE  SANTAROSA  SIGNAL LABEL  MOSTLY 150S SMLR 1.85
PLACER CO BALLOON LABEL 180S LGR HVY 150S LGR  IMMED SHPMT 1.50
PLACERVILLE STGE SACTO 180S LGR  HVY 165S LGR RYMAN LABEL /.80 GOLDEN
AGE LABEL 1.65

BOSC
PLACER CO 180S LGR HVY 135S LGR USONE PROMPT SHPMT /.25
SANTA CLARA VALLEY SAME 1.50
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START OF TYPICAL CONFERENCE CONNECTION. HOME OFFICE IS ADVISING DISTANT UNITS OF LAST MINUTE MARKET NEWS, QUOTATIONS, BIDS, ETC.

involving the G-men. In a surprisingly short time, teletypewriters in as many as 44 field offices are simultaneously typing out the message.

AFTER-BUSINESS-HOURS COMMUNICATIONS

Some customers wish to receive communications during the night or other hours when their offices are closed, or during

the attendant's absence. This need can be met by the special "unattended" feature arrangement mentioned earlier in this article.

Typical of the specific uses some concerns are making of this feature of TWX service is that of a motor freight transportation company which receives communications during the night from its branches as to shipments to be picked up the following morning. The "unattended" messages received during the night are ready for immediate attention the first thing in the morning, assuring minimum delay in getting truck shipments under way.

Often, differences in time between the calling and called station may play an important part in determining how any particular firm may best organize its use of TWX service to obtain the most benefit. For example, concerns with offices on both the East and West Coasts operate under a three hours difference in normal working hours. These time differences have the effect of narrowing the business day and restricting the use of two-way communications. In fact to insure that communications are exchanged during working hours at both ends, TWX connections would have to be established between 12 noon and 5 P.M. E.S.T. with two more hours out if machines are not covered during lunch hours. Some firms with branches on both coasts have found that these time differences can often be effectively overcome by using the unattended service feature. As an illustration, a large clothing concern specializing in women's wear with several branch stores on the Pacific Coast and buying headquarters in New York send all its eastbound communications involving buying requirements, price and style inquiries, etc., which arise after 2 P.M. and before 5 P.M. "Pacific Time" in one or more connections on an unattended basis. This permits the buying headquarters in New York to work on these requirements the first thing the following morning, several hours before the opening of business on the Pacific Coast. Subsequently the New York headquarters may

in turn establish one or more unattended connections—between 9 and 12 noon E.S.T.—and have all replies, new inquiries, prices and data regarding merchandise purchased, advice concerning new style trends, etc., at the Pacific Coast offices at the opening of their business day. Thus—no business time at either end has been lost. Although this example has cited coast-to-coast usage, the same benefits in some degree are being obtained by other firms between any points in different time zones.

Calling Anyone for Written Communication

As mentioned earlier, many firms use TWX service for the less frequent, or perhaps only occasional, communications with other concerns where the speed, two-way and written record features of the service are important, i.e., on a "random" basis. The use of the service by brokers and investment dealers for trading in non-listed securities is quite illustrative of this type of usage. Since there is no central exchange or clearing house through which operations for securities might be centered, the first problem of a dealer commissioned to buy some is to locate a supply which could be purchased at the desired price.

The use of TWX by these dealers now makes it possible for them to call other dealers one after another, anywhere in the country, in order to locate adequate sources. The speed of TWX service enables many potential sources to be reached in short order, so much more rapidly than previously that sending out several inquiries at once is no longer necessary. The two-way feature makes it possible to find out immediately whether and how soon these distant dealers can furnish the desired securities and at what price. In this way a quick job can be done and any unnecessary effort avoided which may arise when several firms reply offering securities simultaneously. Furthermore, experience indicates that the communication cost is

relatively low, such as to keep the cost of doing business low enough to be attractive.

A large steel fabricating concern occasionally receives orders specifying special items or parts not normally made or stocked by that concern. It is often important in placing orders for these items with outside suppliers that deliveries be arranged so that all parts are coordinated properly in final assembly. TWX is used for this purpose since its speed assures a prompt placing of orders and its two-way feature is helpful in reaching quick agreement as to suitable delivery dates.

From such varied usage as is described above, it is evident that American business has found, in TWX, a remarkably efficient and adaptable agency both for routine and emergency interchange of written information. That 12,000 subscribers are already listed in the TWX directory, after only six years of the service's availability, is proof that the Bell System, in developing the service, has met a great need. And, from the six year record of progress, it may safely be inferred that TWX is destined to serve the nation in still greater measure.

R. E. Pierce
J. V. Dunn

The Public Health Aspect of the Telephone

SINCE the discovery of the role of bacteria in disease much attention has been directed to the manner in which they may get from one person to another. Preventive medicine has fostered many sanitary codes in the fight to prevent these minute organisms from entering our bodies through drinking water, milk and food. Sterilization of the doctor's implements has materially reduced the hazards of surgery. Disinfection of our cuts and scratches has become common practice. We are conscious that when we touch doorknobs, stair rails, handles in public conveyances, money and the many objects which others have touched, there is a chance that germs may be deposited on our hands. And now recent research has shown that droplets from the mouth and nose may remain suspended in the air and so be borne to us.

The idea of germs everywhere may lead an unduly timorous person to an attempted avoidance of all the many objects with which our manner of living brings us into frequent contact. The more rational people, drawing upon their experience of general freedom from disease, realize that such an avoidance is futile and unnecessary. They feel, however, that under our complex conditions of living, certain sanitary practices are justified, particularly those applying to our supply of water, milk, and food and to the disposal of garbage and sewage. As to the extent to which it is reasonable to go in preventive measures, they want the guidance of unbiased experts in the field of hygiene and public health.

The fact that the user of the telephone brings the instrument to the head, and particularly near the mouth, has naturally raised the question as to whether this practice plays any appreciable part in the spread of communicable diseases.

Especially has this question been directed at the public telephone with its succession of different users. This matter has engaged the interest of the medical profession, bacteriologists and workers in the field of public health, both in this country and abroad. It has also been the subject of much attention by those responsible for supplying telephone service, both at home and abroad. Information about the experiences and practices regarding this matter has been exchanged between the telephone administrations of Europe and the Bell System. These organizations have sponsored investigations by medical authorities and sought advice from public health experts on this matter.

This combined attention, both inside and outside the telephone business, and the experience with millions of telephones used each day for tens of millions of conversations, have not produced one authenticated case of disease transmission by the use of the telephone. While it is doubtless difficult to prove such a transference, it seems reasonable to assume that the billions and billions of chances would have revealed some cases if it were at all likely to occur.

There has also been a third group who have been at times vigorously concerned with this matter in their own financial interests. There are those who have proposed some device which they claimed was required to make the telephone sanitary. There have been others who have had a formula for some solution which if sprayed or otherwise applied to the telephone would temporarily disinfect it and it has been claimed that some of them would keep the telephone sterile for a considerable period of time by killing the germs which reached it. Others in this group have offered a service of having attendants visit telephone stations and disinfect the telephones—for a monthly fee.

Many of these devices—and there have been many—proposed for attachment to the telephone and designated as "antiseptic" or "sanitary" would interfere with the use of

the telephone without serving any useful purpose. Some of these devices and some of the designated "antiseptic" or "germicidal" solutions have apparently been based on the idea of creating around the telephone instrument a strong odor which presumably would make the user think the telephone had been disinfected and was sterile as long as the odor remained. Some of the solutions proposed would corrode or otherwise damage the instrument. Doubtless their proponents have thought they were trying to sell something beneficial and worth while.

Others unfortunately have tried to reach the potential market of the millions of telephone users by attempting to arouse fear of all the diseases which they claimed might be picked up by the use of the telephone. In some cases attempts have been made to supplement such a campaign of fear by agitating for legislation requiring disinfection of telephones. Their proposals have not been supported by the authorities responsible for public health who generally have been interested in determining whether the suggested regulations would benefit public health and have been guided by the opinions of experts in that field.

With such agitation and with advertisements in the daily papers trying to support a sales campaign by arousing fear of infection in the use of the telephone, it is not surprising that from time to time many queries come to the Bell System asking for its ideas regarding the possibility of disease being spread by the use of the telephone and the matter of disinfection. One such question in 1933 from a member of the public health staff of a large city was answered as follows—stating the conclusions which had been reached from the previous studies and experience—by Dr. C. H. Watson, Medical Director of the American Telephone and Telegraph Company:

> We are familiar with the article of Saelhof and also some researches of still earlier dates. As you have stated . . ., some of the Companies still make limited use of the formalin solution

at public telephone stations. In most of the Companies, this has been succeeded by a regime providing for reasonable cleanliness. We arrived at this conclusion in view of the growing scepticism on the part of the medical profession to so-called safe germicides when used in concentrations necessary to insure sterility. Furthermore, a high degree of bacterial cleanliness would involve a germicidal procedure after each telephone conversation. It has been felt that institution of cleaning routines should depend on the conditions and particularly apply to the public telephones and pay stations. The use of a clean moist cloth to remove mucous debris, organisms and accumulated dust from the exterior surfaces of the transmitter, particularly those portions liable to come in contact with the face, is considered good practice. It is particularly important, however, that no free moisture be allowed to reach the inner parts of the instrument.

From the Saelhof experiment and those of others, it is apparent that the viability of the pathogenic bacteria largely depends on the presence of such human residues as mucous, moisture, etc., deposited in the act of talking. On the other hand, we feel and the facts seem to bear us out, that the telephone transmitter, even when used improperly, is a relatively insignificant source of contamination. As a matter of fact, the organisms must be transferred by contact from a transmitter surface, to the surface of the individual's face, and because of the diameter of the transmitter aperture, this area must include surfaces close to nose, mouth, lips and cheeks. Again from such points, the organisms must be introduced into nasal passages and mouth by secondary contacts, namely, individual's hands and whatever other means are brought into play during the usual activities. The organisms found by Saelhof are the usual pathogens which constitute a large part of the every-day bacterial flora of the upper air passages. Likewise, these same organisms, together with those of the lower bowel tract, are commonly found on the hands of most of the population, and many of the objects of day to day use with which they come in contact, such as paper money, door-knobs, straps, hand rails, etc. Many of these bacterial contact opportunities are of an equal or greater potentiality than the telephone mouthpiece, particularly those which are associated with hand to mouth, and hand to nose, transmission. Furthermore, we have yet to learn of an authentic instance in

all our telephone experience, of an actual case of infection from a telephone transmitter. It would seem that after the many years of telephone use and the millions of exposures, many of which, from what we know, should have been of the most extremely hazardous types, have never brought forth, so far as our records are concerned, an authentic instance of infection.

For that reason, we base our cleanliness procedure on the same reasonable approach which prompts the washing of the hands, the wiping down of hand-rails and other objects with which the community members, particularly in the larger metropolitan districts, are so frequently in contact.

The above statement is a generalization of our feeling in this matter.

A similar statement by Dr. H. E. McSweeny, Medical Director of the New York Telephone Company was published in the New York Times on July 11, 1934.

Investigations by medical and health authorities and the experience of the telephone company indicate that the telephone transmitter is not to be considered as a source of infection. The use of the telephone is not attended by even the slight risk encountered in the case of many objects of daily use with which a person comes in contact.

Germs which may be deposited on such exposed surfaces are generally short-lived. Further, such organisms must be transferred by actual contact from these surfaces to such places as the face and hands of the user and then introduced by further action into the nasal passages or mouth.

If it is desired to clean the telephone mouthpiece, wiping with a cloth is usually adequate and, if necessary, the cloth may be damp. The cloth should not be sufficiently wet to introduce moisture into the transmitter since this may interfere with the operation of the telephone.

Although these conclusions appeared to be well founded by previous investigations and experience, because of the importance of this matter, arrangements were made in 1934 to get further information. It was decided to have two independent investigations by competent authorities who could bring to this matter the best bacteriological techniques and

would represent the expert opinions in the field of public health. On the advice of outstanding authorities in medical research, arrangements were therefore made to have such investigations carried out under the direction of the late Dr. E. O. Jordan,* then Distinguished Service Professor of Bacteriology in the Department of Hygiene and Bacteriology, University of Chicago, and of Dr. Haven Emerson,* Professor of Public Health Practice in the Institute of Public Health, College of Physicians and Surgeons, Columbia University.

Both Dr. Jordan and Dr. Emerson were asked to have carried out under their direction whatever work they considered necessary to enable them to arrive at conclusions as to the possibility of disease transmission in the use of the telephone. One investigation was made in Chicago and the other in New York. Participation of the operating telephone companies in the two localities was limited to arranging access to the telephones which the investigators selected to visit and providing the facilities which they needed.

The bacteriological work under Dr. Jordan was carried out by Dr. S. A. Koser, Associate Professor of Bacteriology, and Dr. J. M. Birkeland, then on the staff of the Department of Hygiene and Bacteriology and since Assistant Professor of Bacteriology at Ohio State University. The independent investigation at Columbia University was undertaken in the De Lamar Institute of Public Health by Dr. C. B. Coulter and Dr. Florence N. Stone.

These two investigations have now been completed and reports made of the bacteriological studies. Those directing the investigations have also made statements as to their conclusions regarding the public health aspects. The report of the Columbia University work has been published in the American Journal of Public Health, October 1937. The report of the University of Chicago work has not as yet been published.

* Brief records of these two men, distinguished in public health and allied fields, are to be found in the 1936–1937 issue of Who's Who in America.

In both studies the general procedure was the same. A bacteriologist went to each of the telephone instruments which he had selected, wiped a sterile moistened swab over the mouthpiece of the telephone transmitter and then in the laboratory made cultures from the swab to determine the kind of bacteria present. In the Chicago study 100 public telephones were so examined in a general search for various kinds of bacteria and 100 additional telephones in a specific search for the presence of tubercle bacilli. In the New York study 246 telephones, most of them public telephones, were so visited and examined. Tests were also made in the laboratories to cover other phases of the problem.

In both studies harmless bacteria were found on many instruments and certain types of disease-causing or pathogenic bacteria were found on some instruments. In the Chicago study no diphtheria, pneumonia or tuberculosis bacteria were found. In the New York study no diphtheria bacteria were found, but some pneumonia types were revealed in the winter and spring months.

In the Chicago study, for the 100 telephone locations included in the general survey, swabbings were made not only from the transmitter mouthpiece but also from the receiver earpiece, the receiver shell and the handle of the door of the booth. The purpose of taking cultures from these four surfaces was to determine the occurrence of bacteria on a surface exposed to the mouth while talking, relative to the occurrence on other surfaces with which contact was made by hand, ear, or other parts of the body. The earpiece surface showed slightly more than the transmitter mouthpiece, while the receiver shell and the door handle which were about equal, showed somewhat less. This would indicate that objects exposed to the mouth when talking are in the same range as repositories for bacteria as objects with which contact is made by other parts of the body.

Also in the Chicago study an investigation was made of the longevity of bacteria deposited on the transmitter mouthpieces. It was found that in general 90 per cent of most kinds of bacteria were dead within one hour and nearly as many within the first 15 minutes. This is supported in the New York study by the finding that "since the number of bacteria which may be recovered from a telephone in constant use is often no greater than the number which may be deposited in a single conversation, it is evident that there is no tendency toward the accumulation of living bacteria on the transmitter." There is also some indication in these studies that the exposure of pathogenic bacteria on the transmitter mouthpiece, causes a material loss in their potency. In the New York study some of the potentially pathogenic streptococci obtained from the surface of the telephone instruments were found in fact to be non-pathogenic for laboratory animals.

In laboratory studies it was found that types of bacteria which were known to be in the mouths and nasal passages of a talker could subsequently appear on the transmitter mouthpiece surface, but this was not always the case.

It was also shown by both groups of investigators that there was relatively small chance of bacteria on the mouthpiece of a transmitter being removed by talking into it or of being picked up by the talker.

The public health conclusions as derived from these studies are best expressed by quoting from letters of Dr. Jordan and Dr. Emerson to Dr. F. B. Jewett, Vice President of the American Telephone and Telegraph Company.

Dr. Jordan's letter of July 31, 1935 reads as follows:

> I am transmitting herewith the report of Professor S. A. Koser and Dr. J. M. Birkeland relating to the possible role of telephones in spreading communicable disease.
>
> Briefly the results of the work are as follows:
>
> I. Bacterial examination of the mouthpieces of frequently used public telephones in various parts of the city of Chicago

showed, as might be expected, the presence of bacteria. These belonged chiefly to the types commonly found in air and dust, and, as appears in Table 1 (page 6), were not noticeably different in kind from those present on the door knobs of the telephone booths. Although intensive search was made for diphtheria bacilli and pneumococci, these microörganisms were never found. No tubercle bacilli were found, either by cultural methods or by animal inoculation. The reason for what may appear the rather surprising scarcity of respiratory tract organisms is explained in the following sections.

II. Laboratory experiments were devised to determine the longevity of bacteria smeared in large numbers directly on the mouthpiece. These observations showed that the common pathogenic organisms perish quickly under these conditions, over 90 per cent of most kinds dying within one hour and nearly as many within the first 15 minutes. This is in accord with general bacteriological experience that the life of most disease germs outside the animal body is very brief. The tubercle bacillus is well known to be more resistant to drying than many other bacteria, but even as regards this organism it is evident that considerable reduction in numbers takes place early. In all such experiments it is well known that a few especially resistant cells may survive for a number of days. It need hardly be pointed out that the bacterial contamination of the mouthpieces in these experiments is far greater than would be likely to occur in the practical daily use of any public telephone. The rapid death of respiratory tract bacteria outside the body is undoubtedly one reason why few of these organisms are found on telephone mouthpieces in constant use.

III. The possibility of transferring bacteria from mouth or throat to telephone mouthpieces in the course of conversation was tested in a variety of ways with the result that occasional transfer could be readily demonstrated. It was of particular interest, however, that with large numbers of test organisms in the mouth and throat and with telephone conversations lasting three minutes and sometimes longer, immediate examination of the mouthpieces frequently failed to reveal the transfer of any of the test organisms. After the use of the telephones for a conversation of two minutes by a demonstrated carrier of diphtheria bacilli no diphtheria bacilli were recovered from the mouthpiece.

IV. Experiments to determine the possibility of transfer of bacteria from telephone mouthpieces to the mouth of persons using the telephones showed that when the lips, cheek or fingers did not come into direct contact with the freshly inoculated mouthpiece no transfer of the test organisms occurred.

The conclusions that may be legitimately drawn from the experiments by Professor Koser and Dr. Birkeland, just summarized, together with previous experiments on this and similar problems, are as follows:

1. Numerous opportunities exist for picking up bacteria, including some disease germs, from our surroundings. Every city-dweller is likely to come in actual contact many times a day with bacteria on such objects as door knobs, chair arms, books, coins and paper money, playing cards, street car straps and the like, as well as on telephones. Some of these germs may be from the human alimentary tract or respiratory tract. It is practically impossible to avoid all or most of these contacts. Practice of personal hygiene, such as handwashing before meals and the avoidance of contacts between fingers and nose or mouth, seems the only effective way of protection against this possibility of disease transmission.

2. It is well recognized by sanitarians that whatever may be the danger of disease transmission from inanimate objects it is far less than from the living human carrier of infection. The role of paper money, of public library books, of articles of furniture in rooms used by diphtheria or scarlet fever patients, in spreading infection has been studied by a number of workers and has never been shown to be very important. Routine terminal disinfection or fumigation after all cases of infectious disease has now been quite generally abandoned by health authorities since it has not been found effective in reducing the amount of new infection. In Providence, R. I., for example, the records show that the number of new diphtheria cases occurring among 1457 families in which fumigation was practised after a case of diphtheria was 1.71 per cent, while in 3000 families without fumigation the proportion of new cases was almost exactly the same (1.8 per cent).

3. With respect to the particular danger from telephone instruments, the infectious hazard seems no greater than from scores of other objects. Bacteria from the mouth that may be

deposited occasionally on the telephone mouthpiece are of course not dislodged by air currents. While direct contact with lips or fingers may remove bacteria from any surface, this occurrence is entirely under individual control.

Taking into consideration the relatively small numbers of bacteria transmitted from the mouth to the telephone mouthpieces and their short life in this situation, and also the evidence that disease germs on the mouthpieces of much used public telephones are certainly not common and probably exceedingly rare, and having in mind the fact that contact with fingers, lips or tongue is a matter within the control of the individual as completely as the tongue-moistening of postage stamps, it is my belief that routine disinfection of all public telephones would not be a justifiable public health requirement. To be of any conceivable practical value such disinfection would have to be carried out after each use of the instrument. Even so there would remain so many other sources of contact for every active city-dweller that the effect of such disinfection on the spread of disease would in my opinion be negligible.

This is supplemented by a subsequent statement from Dr. Jordan's letter of April 20, 1936.

The bacteria found on the telephone receiver do not seem to me important from the public health standpoint. They are obviously mainly rubbed off from the skin or hair and are probably protected somewhat against drying by a slight oiliness. My conclusion that routine disinfection of public telephones would not be a justifiable public health requirement applies to the receiver as well as to the transmitter.

The following statement is taken from the letter of September 23, 1937 written by Dr. Haven Emerson:

Now that the publication of the report by Drs. Coulter and Stone on their bacteriological studies on the public telephone is assured in the American Journal of Public Health for October, you will, I trust, permit me to express on behalf of our staff as well as for myself individually, our appreciation of the conditions under which you made the grant for this work available.

The entire independence of those engaged in the studies both in the manner and content of the work and in the deductions

drawn from it has been at all times assured by your request that the matter be approached with scientific objectivity.

It will appear, I believe, to any one trained in sanitary science and epidemiology, as it does to all of us here, that the findings of the bacteriologists amply confirm the generally held belief that the occasional contact by ear, hand and mouth, with one or other part of the telephone receiver or transmitter adds no hazard or risk of infection to the user or to the community, which does not exist in a multitude of other more direct, frequent and widely spread exposures due to usual human activity and relationships.

Fresh and dried discharges from the upper respiratory tract may spread various of the communicable diseases, but the chance of such conveyance of disease by healthy carriers, or by unrecognized or incipient or convalescent spreaders of pathogenic organisms through the use of the public telephone appears too remote to justify personal or official action in the interest of health protection, other than the usual precautions of ordinary cleanliness and a proper consideration of public decency.

As a result of conferences and staff discussions following the presentation of the Coulter-Stone report and with the study by Dr. Jordan's colleagues, Dr. J. M. Birkeland and Professor S. A. Koser in hand, my associates here, Professor Earle B. Phelps and Dr. M. L. Isaacs of the Department of Sanitary Sciences and I have expressed our combined opinion on the matter at issue as follows:

Health officers of some of the larger cities and of some states in North Eastern United States have within recent years been subject to pressure of a commercial and political nature, to persuade them to initiate official control of the public telephone instrument as if it were a substantial sanitary hazard contributing to the spread of those communicable diseases transmitted by discharges of the nose and throat.

Critical analysis of the evidence for and against the existence of such a hazard has been lacking until now because of the inadequacy of the bacteriological information offered and the uncertainty as to the reliability of the technical procedures used in discovery of the kinds and numbers of bacteria obtained from either the receiver or transmitter apparatus of the telephone instrument.

The painstaking studies reported by Coulter and Stone, and Koser and Birkeland, represent an important advance in our knowledge of the situation which may be summarized briefly as follows:

Bacteria of wide variety are to be found on the telephone mouthpieces with but little relation to the frequency and conditions of use of the instruments. Among these the saprophytes ordinarily found on all articles exposed to general air circulation predominate. Cocci of numerous pneumococcus and a streptococcus varieties are also found. Some of these are recognized as being pathogenic and might give rise to human infection if inhaled or removed by lip contact in sufficiently large doses by persons with a relatively low resistance to the particular strains in question.

Some of the potential streptococcus pathogens obtained from the surface of telephone instruments were found in fact to be non-pathogenic for laboratory animals.

The process of talking in a telephone mouthpiece removes but very few of the bacteria which may have been recently deposited by a previous use of the instrument.

Until the requirement and technique of our ordinary conduct of life has gone far beyond any present common practice, the telephone mouthpiece will continue to create no greater sanitary hazard than that of the hand rail, the door knob, and articles in frequent contact with human hands and exposed to airborne dust.

No sanitary code authority and no time, money or personnel of health departments should be applied in a vain hope that communicable disease will be to any extent reduced by some theoretically possible but practically futile compulsory antibacterial measure intended to make the telephone instrument even occasionally or intermittently sterile.

With the bacteriologist's facts and resources available to us, and no epidemiological evidence running counter to their conclusions, it ought not to be possible for legislatures, city councils, or boards of health to be forced into injudicious and profitless sanitary regulation of the public telephone.

These conclusions of Dr. Jordan and Dr. Emerson that the telephone is unimportant from the standpoint of public health are of interest to many—to the large telephone using public

and also to those responsible for providing telephone service. To the latter, it is gratifying to know that the current bacteriological and public health findings confirm the past opinions and experience that the telephone instrument has no greater potentiality in transmitting disease than the many other objects of daily use. To the telephone users, and particularly those to whom this may have been a matter of concern, it should be reassuring to have authoritative advice that, as regards the possibility of transmitting disease, they can treat the telephone as they do other objects with which they come in daily contact. Furthermore it is well recognized that such inanimate objects are far less important in public health considerations than exposure to and contact with human carriers of infection.

W. H. MARTIN

The Origin and Development of Radiotelephony

(A paper presented before the Institute of Radio Engineers, May 10, 1937)

UPON this, the Silver Anniversary of the Institute of Radio Engineers, it is appropriate to recall how there came into being the art of radiotelephony and, in turn, such services as overseas telephony and broadcasting. The Institute has seen the entire evolution within its relatively short life, with radiotelephony an unsolved problem in 1912 and today an accomplished fact of world-wide application.

The pages of the Institute Proceedings testify to much of the building of the art, but nowhere has there been given a unified account of the structure as a whole and the relation of its technical substance to electric communications generally. To do this objectively and while the development is still fresh in mind is the purpose of the present paper. Naturally, the story is limited by space and by the information available to the writer. Most of the account pertains to America. If the contributions of other countries are not adequately presented, it is because the limitations of time, space and language have not yet been entirely overcome.

Background in the Physical Sciences

It is well to acknowledge, in the first place, the debt which radio owes to the more fundamental contributions from the physical sciences, the more pertinent ones of which, underlying as they do the entire art of electric communications, may be epitomized as three major waves of advance:

The great transition which occurred in the early 1800's from the electrostatic to the electric current and electromagnetic state of electrical science, which led to the telegraph

and later to the telephone (to say nothing of electric power).

The conception and demonstration of electromagnetic wave propagation and electric oscillations, notably by Maxwell and Hertz. This advance applied to guided as well as unguided wave propagation, and is the basis of the transmission art of both wire and wireless communication.

The proof of the corpuscular nature of electricity and its identity with matter, the basis of twentieth century physics and of electronics.

Early Experiments

It happens that an early attempt at transmitting speech without wires was made by the inventor of the telephone himself, Alexander Graham Bell. Back in the 1880's he sent speech over a beam of light, using reflectors in much the same way that ultra-short waves are directed today. He called the system the "photophone." Mercardier rechristened it the "radiophone" because it employed frequencies not limited to the visible range, and here we have the earliest use of the word "radio" in the sense employed today.

Of course, the more direct forerunners of radiotelephony were wire telephony and wireless telegraphy. The transmission side of both these arts came out of the early work of Maxwell and Hertz, but they developed for many years quite independently, because of the great difference in the transmission frequencies involved. Early attempts at carrier-current telephony and telegraphy over wires, involving frequencies of tens of thousands of cycles and utilizing modulation, frequency-selecting circuits and detection, were unsuccessful because of the lack of suitable technique even for those frequencies, and were in general unknown to later wireless telegraph experimenters. The devices with which Marconi initiated practical wireless telegraphy were adapted to frequencies of the order of a million cycles, generated discontinuously by

means of sparks. In time wireless telegraphy evolved toward the use of continuous waves and, by such means as the high-frequency alternator and the oscillating arc, bridged the gap between the radio and the wire frequency ranges.

In the period of 1906–1912 radiotelephony was an experimental fact but a practical non-reality. Many were the early experimenters who had succeeded in transmitting speech over distances of some miles, notably Fessenden and De Forest in America, and Majorana, Vanni and Poulsen in Europe. In 1911 General Squier, of the U. S. Signal Corps, brought widespread attention to the possible application of the then wireless instrumentalities to high-frequency transmission over wires.

But radiotelephony remained for the radio experimenter a golden goal of attainment, for there were wanting practicable means for generating the high-frequency currents, for controlling them in accordance with the relatively weak waves of speech and for renewing at the receiving end the waves so greatly weakened in transit. The story which follows of the successful meeting of these problems, principally by means of the vacuum tube, is broken by the incidence of the Great War into three periods.

The Formative Period of 1912–1916

In retrospect, it is now apparent that by about the time of the formation of the Institute the general front of technical advance had reached the point of almost inevitably yielding the solution of the radiotelephone problem. The two-element and three-element vacuum tubes existed, knowledge of thermionics and means for attaining higher vacuua were accumulating, coupled tuned circuits were well known, and in wire telephony the basis had been laid in the loaded-line theory for the electric wave filter and circuit network philosophy. But lest the attainment of radiotelephony seem too easy, let us follow in a little more detail how the structure of the art was built. The scene is placed in America principally, for it was here that De

Forest was experimenting with his three-element audion tube, that telephony generally was developing apace, and that certain research laboratories were working upon problems which needed the tube.

The High-Vacuum Tube

Dr. Lee De Forest invented the three-element tube in 1906–1907, but it was not until about 1912 that he succeeded in adapting it under some circuit conditions to operate as a true amplifier. In the fall of that year he and an associate, John Stone Stone, demonstrated the audion to engineers of the Bell System in the role of an audio amplifier, a candidate for the solution of the telephone repeater problem. The device was still a weak and imperfect thing, had in the grid circuit the familiar blocking condenser of the audion detector, and was incapable of carrying any considerable voice load without blue hazing; yet, it *was* capable of amplifying speech.

Among those in the telephone laboratory who witnessed De Forest's demonstration was one H. D. Arnold, then fresh from the study of electron physics in Dr. Millikan's laboratory of the University of Chicago. Whereas there had always been confusion of thought concerning the effect of gas upon the operation of the audion, Arnold immediately recognized that what was wanted was a pure thermionic effect, free of gas complications. He set to work to produce a higher-vacuum tube, using evacuation methods then only recently available. He succeeded and, once and for all, took the three-element tube out of the realm of uncertainty and unreliability and made of it a definite, reliable, amplifying tool.

About the same time that Arnold was doing this in the laboratories of the telephone company, principally in 1913, Langmuir, in the laboratories of the General Electric Company, studying the problem of x-ray tubes and power rectifiers, arrived at substantially the same result. In a patent contest lasting many years the Supreme Court of the United States gave to Arnold

the credit of having been the first to attain the truly high-vacuum tube and agreed with Arnold's original viewpoint, that this step, important though it was, did not constitute invention over the prior art.

By the time the high-vacuum tube was obtained several gaseous forms of tubes had appeared. One of these was of the mercury-vapor type, employing magnetic control, which was being worked upon by Arnold as a telephone repeater at the time the audion was first called to his attention. Another was the tube of von Lieben and Reisz, of Austria and Germany, which employed a grid element. All such gaseous devices were soon eclipsed by the high-vacuum tube.

The high-vacuum tube was further improved in 1913 by the application to it of Wehnelt's oxide-coated cathode. The filament electron emission was thereby increased, producing the dull-emitter type of long-life tube. The vacuum tube in this form, stable, with adequate filament emission and long life, set the pace in the amplifier art from that time forward and was the practical basis of the succession of further developments which resulted in practical radiotelephony. One of De Forest's audions and one of the early high-vacuum telephone repeater tubes are pictured in Figure 1.

Oscillator

One of the next developments was, of course, the conversion of the vacuum tube amplifier into a generator of high-frequency currents. This was accomplished first by De Forest in 1912, according to a decision of the United States Supreme Court. Others did it independently about the same time, notably Armstrong here and Meissner in Germany. Armstrong's 1915 Institute paper upon the subject was a notable one, as was evidenced by the demand for the issue of the Proceedings in which it appeared. Particular forms of oscillating vacuum-tube circuits were developed by other investigators, including

C. S. Franklin and H. J. Round, of the British Marconi Company, and Colpitts and Hartley, in the United States.

The earliest uses known to have been made of the oscillator in radiotelephony are the experiments of Meissner in Germany in 1913, between Berlin and Nauen, using the von Lieben-Reisz tube, and of H. J. Round, of England, early in 1914, in experimental transmission between two ships.

Modulator

Another major step, the invention of the vacuum-tube modulator, soon followed. This solved the problem of enabling low-power voice energy to control the considerably higher-power waves required for radiotelephone transmitting, and enable this control to be exercised remotely over a telephone line, thereby giving through transmission between wire and radio circuits. The earlier attempts at radiotelephony had depended for modulation upon the carbon microphone, usually worked directly in the antenna-ground circuit. Here, again, we have a case of several investigators arriving at the invention at about the same time, 1913–1914, with Alexanderson, of the General Electric Company, and Colpitts, of the telephone laboratories, sharing the honors. Other modulating circuits followed. The telephone engineers had in mind doing the modulating at low power and then amplifying the modulated current by means of a high-frequency amplifier.

High-Frequency Vacuum-Tube Telephony

By the latter half of 1914 there was within grasp in the telephone laboratories sufficient of the high-frequency technique, based upon the high-vacuum tube, to cause the telephone engineers to set about the development of high-frequency telephone systems. The first attempt was at the wire carrier-current problem. A two-channel multiplex system was set up using vacuum-tube oscillators, modulators, amplifiers and detectors. The result was decidedly encouraging. Since the

same instrumentalities were applicable to radiotelephony, there was next undertaken the development of a vacuum-tube radiotelephone system.

These early wire carrier-current and experimental systems proved to be the precursors of our modern art. They mark a climax in what is perhaps the most rapid accretion of technique known in modern electric communications, from the condition, in the fore part of 1912, of there being no suitable generator nor modulator, to that of 1914–15 where these essentials had become available and were being synthesized into operative high-frequency telephone systems.

Long-Distance Tests of 1915

Vacuum-tube radiotelephony was now to be taken out of the laboratory for a field trial. A vacuum-tube transmitter of a few watts output was developed and installed at Montauk Point, Long Island, and an amplifying receiver was located at Wilmington Delaware, 200-odd miles distant. The distance was then stretched to some 600 miles by receiving the Montauk transmitter at St. Simons Island, off the coast of Georgia. These were one-way transmissions. For some of them the reception was brought back to New York by wire lines. The speech was itself clear, but was sometimes buried in noise due to the small transmitting power and the fact that it was the spring of the year. Wavelengths of 800 to 1800 meters were employed.

The success of these preliminary tests, together with the promise of laboratory developments for higher-power transmitting tubes, now led to a bold attempt on the part of the telephone engineers to overcome that great natural barrier of telephony, the oceans. Through the cooperation of the United States Navy Department, on the one hand, and the French Administration, on the other, appropriate field stations were made available for the tests. The large antenna of the naval station at Arlington, Virginia, was used for transmitting. A

new vacuum-tube radiotelephone transmitter was developed, employing hundreds of tubes, each having a capacity of the order of 15 watts, and installed at Arlington. For reception the Navy Department made available their stations at the Canal Zone, on the Pacific Coast and in Hawaii. Through the kindness of Gen. Ferrié, of the French Administration, use of the Eiffel Tower station was permitted the American telephone engineers for receiving purposes. Thus did the French collaborate in the interest of technical advance and international good will by accepting foreign engineers in their most important military station during the life-and-death struggle of the Great War.

By June all the distant receiving points were covered by engineers who had been dispatched from New York provided with the then latest receiving apparatus; the new telephone transmitter had been installed at Arlington; a great effort was being made in the laboratories to produce the necessary quantity and quality of power tubes. The tests continued on and off during the entire summer on a reduced power basis, during which the difficult atmospheric conditions were studied by the receiving engineers. As the conditions improved with the coming of fall and as the transmitting power was built up, results began to be obtained, first, from Panama; next, from the Pacific Coast, representing transmission across the continent; then, from more distant Hawaii; and, finally, in November from Paris, where the receiving conditions had proven to be most difficult.

These were, of course, one-way transmissions. The reception was so uncertain and so subject to noise as to make it evident that the art would need to be advanced greatly before the requirements of a service could be met over such long distances.

Some of the technical features of the apparatus of these early tests were:

In the transmitting station, the use of the master-oscillator, power-amplifier type of circuit, operating in the 30 to 100-

kilocycle range, with circuits designed to accommodate the "carrier and sideband" aspect of the modulated wave.

The development of power tubes of the order of fifteen watts, requiring new designs and more thorough pumping and degassing.

The operation of large numbers of tubes in parallel (as many as 500), in order to build up the necessary transmitting power. The problem of operating these tubes in parallel and preventing singing can well be imagined. An average power of two or three kilowatts was obtained in the antenna. A photograph of two banks of 250 tubes each is reproduced in Figure 2, the tips of some of the tubes showing on the right.

Receivers employing a radio-frequency amplifying stage, plus two audio-frequency stages. Heterodyne detection was employed to find the carrier. Homodyne reception of the telephone signals was used at some of the receiving points.

The following year, 1916, tests of radiotelephony were made for the United States Navy, which included what is believed to have been the first attempt at tying together radio and wire lines for through two-way radiotelephony. The Secretary of the Navy, Josephus Daniels, talked from his desk in Washington, D. C., with the master of the *U. S. S. New Hampshire,* off the Chesapeake Capes. During this year Heising devised his now well-known "constant current" system of modulation, the simplicity of which led to its use in the radiotelephone sets which were produced during the war and in the early radiobroadcast transmitters. Incidentally, early in this same year there was undertaken anew the problem of carrier-current telephony and telegraphy, this time looking toward commercial designs, utilizing the newly acquired instrumentalities of the vacuum-tube and the electric wave filter. The application of the vacuum-tube amplifier to voice-frequency telephone circuits was also proceeding apace.

Radiotelephony was now progressing rapidly, building upon and, in turn, stimulating its antecedent and contemporary arts of wire telephony, wireless telegraphy and electronics. Something of the content of these related arts is indicated below:

ARTS UNDERLYING RADIOTELEPHONY

Wire Telephony	*Wireless Telegraphy*	*Electronics*
Electroacoustics Transmitters, receivers, characteristics of sound, high-quality reproduction.	Generators and receivers of high-frequency currents; selective circuits.	Discovery and study of the electron (Crookes, J. J. Thomson and others).
Wire Transmission Propagation constant, characteristic impedance, transmission measurement, interference, carrier, wave filters and network theory.	Antennas Dipole (Hertz), grounded (Marconi). directive.	Thermionics (Richardson, Wehnelt and others).
Amplification Microphone, repeaters.	Wave Propagation Spreading and absorption, ground and sky waves, effects of solar and meteorological phenomena.	The Edison effect and the Fleming valve. De Forest 3-electrode tube. High-vacuum, high-power and multi-electrode tubes.

THE WAR PERIOD

The war came to Europe before the new vacuum tube art and radiotelephony had been fully born. Vacuum tubes were employed in the war by the European countries for radiotelegraphy, but radiotelephony is not known to have played a part on the continent. This may have been due in part to the lack of secrecy of this form of communication.

In the United States the normal development of radiotelephony continued, as we have seen, up to the time of this country's entry into the war. The new vacuum-tube radiotelephony had by then assumed real promise. The United States Government undertook to develop two-way radiotelephone sets on a large scale for dispatch purposes on submarine chasers and airplanes. In the short space of a year or so hundreds of thousands of tubes and thousands of sets were developed and manufactured. Several of the larger laboratories of the country were in effect taken over by the government for this purpose. The apparatus was featured technically by:

The general use of the high-vacuum, oxide-coated filament type of tube.

Employment of the constant-current type of modulation.

The attempt to make the operation of the sets simple and foolproof, as by the elimination of filament rheostat and the standardizing of tubes and circuits to permit of ready interchangeability.

Such apparatus was used in some quantity on submarine chasers of the Navy, but the large production program for airplanes was not completed in time to enable radiotelephony to come into play in the Army on the battle front. From the technical standpoint the program stimulated apparatus design and gave a useful experience in the standardization and quantity production of tubes.

Through the many military training schools in the United States the new vacuum-tube radiotelephone art was "broadcast" to the most likely young men of the country, many of whom developed a real interest and after the war helped to swell the peacetime development.

Post-War Developments

The peacetime development of the art was now immediately renewed, especially in the United States where the technical effort had been sustained through the war. It became evident to the several large companies which were pursuing the vacuum-tube art, particularly the American Telephone and Telegraph Company and the General Electric Company, that their inventions so interleaved as to require an exchange of patent rights. This took the form of an inter-licensing agreement, entered into between these two companies in 1920. It enabled the telephone company to use tubes on its lines and to proceed with the development of two-way radiotelephony. The General Electric Company and its affiliates, including the Radio Corporation of America, were free to proceed in other fields,

principally radiotelegraphy, and, as it turned out, in broadcasting.

Early Ship-to-Shore Telephone Experiments

The telephone company had by this time undertaken development work in marine radiotelephony, partly as a means of advancing the art and partly with an eye toward the eventual establishment of a mobile public telephone service connecting with the land line system. Experimental shore stations were provided (one of which, that at Deal Beach, New Jersey, is shown in Figure 3), and ship apparatus capable of duplex operation was devised and tested on coastal vessels and on one of the transatlantic liners. This work was done in the frequency range then most available, that of the order of a million cycles. Shortly thereafter broadcasting preempted this range and because of this and of the post-war depression in shipping, these experiments did not then materialize into a service. Trial connections with the land line network extending across the continent and to Catalina Island served to demonstrate the possibilities of combined wire and radio working. Some of the technical attainments in this work were:

The development of duplex systems for ship use.

The development of superheterodyne receivers.

Progress in placing radio transmission upon a quantitative basis by the measurement of received field strengths and the overall circuit equivalent of radio links, and in the setting up of radio links as integral parts of long landline connections.

The beginning of the volume indicator, used to insure the voice loading of the radio transmitter and later employed extensively on wires, as well as in radio.

First Public Telephone Service by Radio

Another pioneering undertaking about this time, 1920, was the development of what proved to be the first use of radio-

telephony for public service, in the form of a point-to-point link on the Pacific Coast between Catalina Island and Long Beach on the mainland, connecting thence to Los Angeles. Service was given over this link for about a year, when the frequency band being used was wanted for the then newly developing service of broadcasting. The telephone service itself came near being a broadcast one, so extensively were the conversations listened to by amateur radio enthusiasts. The system was replaced by a submarine cable.

From the standpoint of technical progress, this installation included a number of interesting features:

Full-duplex operation in the sense of separate channels for the two directions of transmission, joined at the terminals to the two-wire telephone network by means of hybrid coils.

Through voice-frequency ringing, the first application to radio.

Superheterodyne receiving sets, incorporating wave filters in the intermediate frequency stages which separated out:

A telegraph channel which was superimposed upon, i.e., multiplexed with, the telephone channel and used independently for telegraph service with the Island.

The provision toward the end of the period of means for rendering the telephone transmission private, comprising voice inverters, plus carrier-frequency wobbling, the first installation of this combination to have been made.

The picture of the Long Beach receiver in Figure 4 shows at the top a portion of the loop receiving antenna; in center foreground, the circuit control desk; above, to the right, the speech inverter for privacy; and, in the left background, the apparatus of the superimposed telegraph channel.

Broadcasting

By 1920–1921 the stage was set in the United States for radiobroadcasting. A radiotelephone technique was becoming available in the relatively empty portion of the frequency range centering about one megacycle. Something of an audience

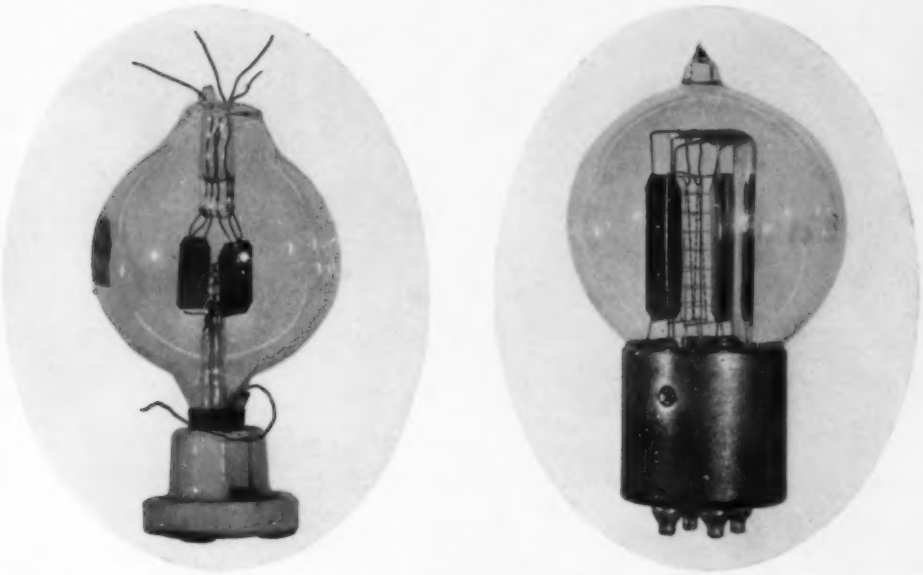


FIG. 1. ONE OF DEFOREST'S AUDIONS AND AN EARLY HIGH-VACUUM TELEPHONE REPEATER TUBE OF TWENTY-FIVE YEARS AGO.

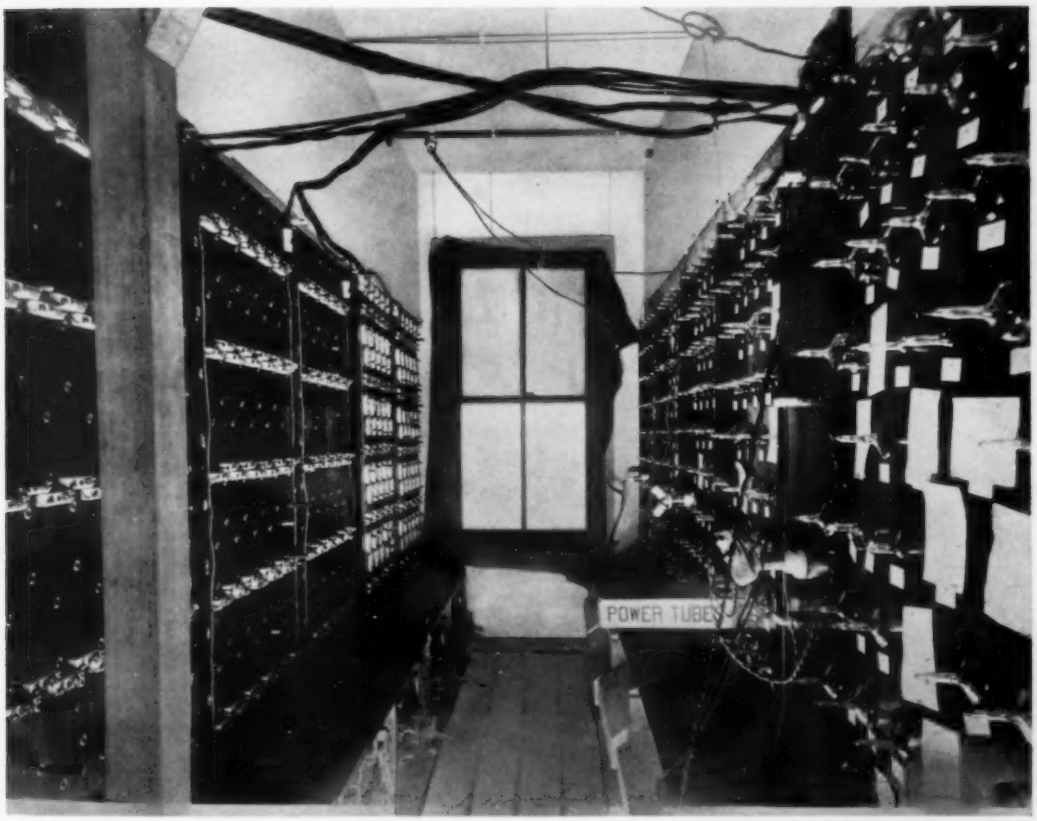


FIG. 2. AT THE RIGHT OF THE PICTURE ARE SOME OF THE 500 TRANSMITTING AMPLIFIER TUBES USED TO PROJECT THE FIRST HUMAN VOICE ACROSS THE ATLANTIC IN 1915.

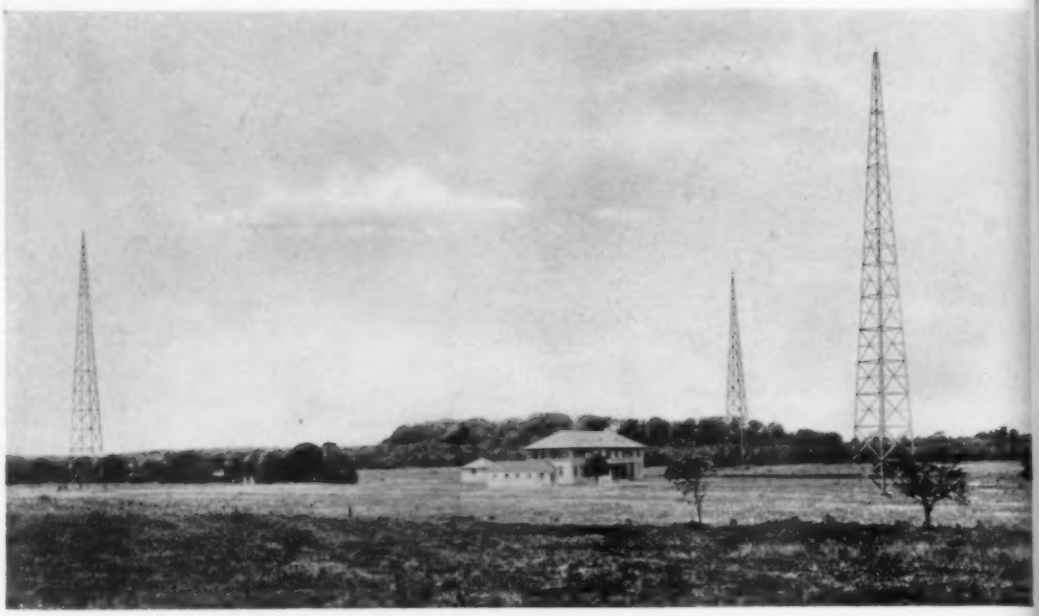


FIG. 3. AN EXPERIMENTAL SHORE STATION FOR MARINE RADIOTELEPHONY WAS ESTABLISHED AT DEAL BEACH, N. J. SHORTLY AFTER THE CLOSE OF THE WORLD WAR.

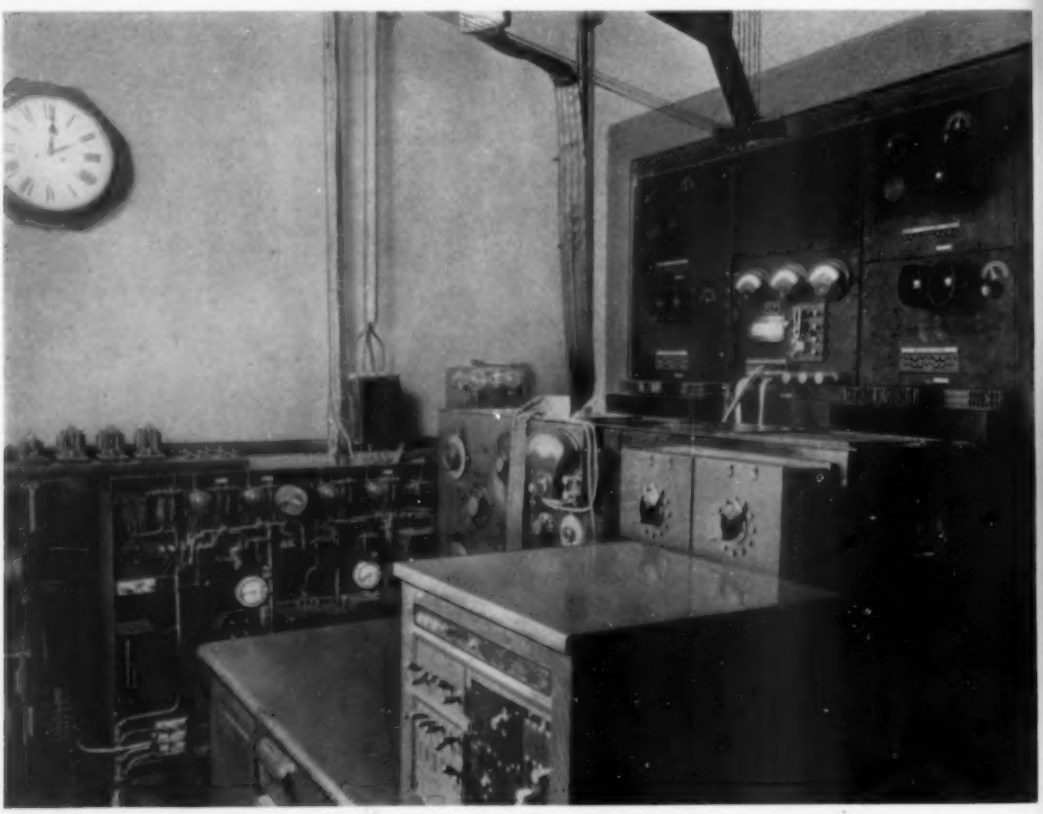


FIG. 4. THE FIRST USE OF RADIOTELEPHONY FOR PUBLIC SERVICE—LONG BEACH, CALIF., RECEIVER FOR CONVERSATION WITH CATALINA ISLAND IN 1920.

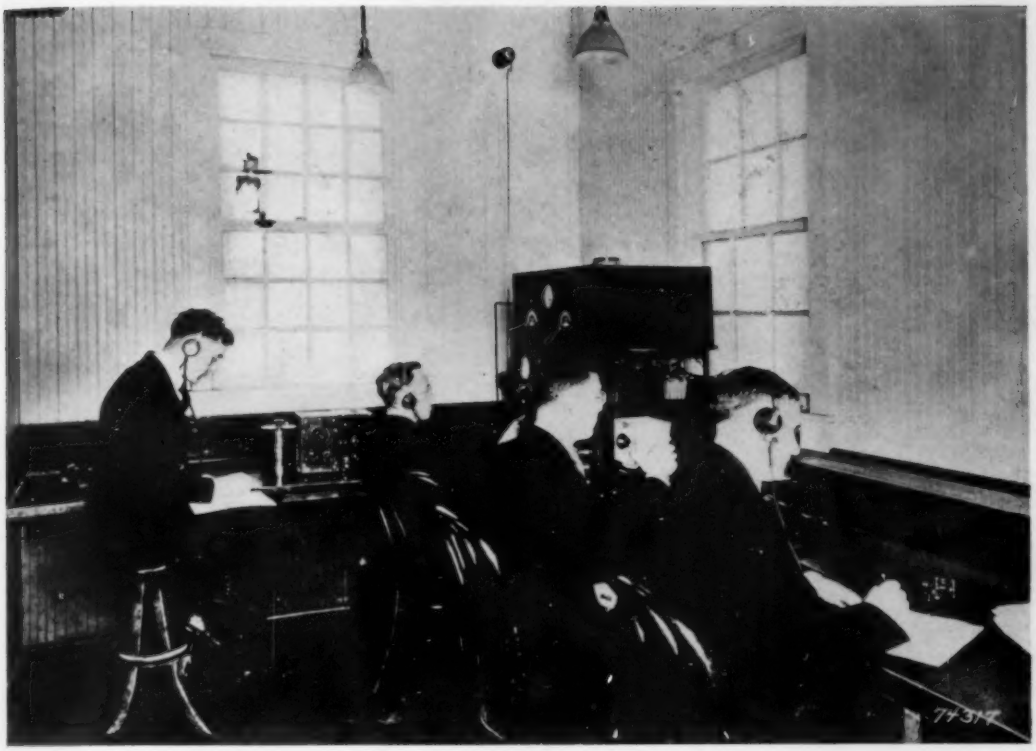


FIG. 5. HISTORIC SCENE AT THE ORIGINAL TRANSMITTER OF KDKA ON THE OCCASION OF ITS FIRST BROADCAST, THE PRESIDENTIAL ELECTION ON NOVEMBER 2, 1920.

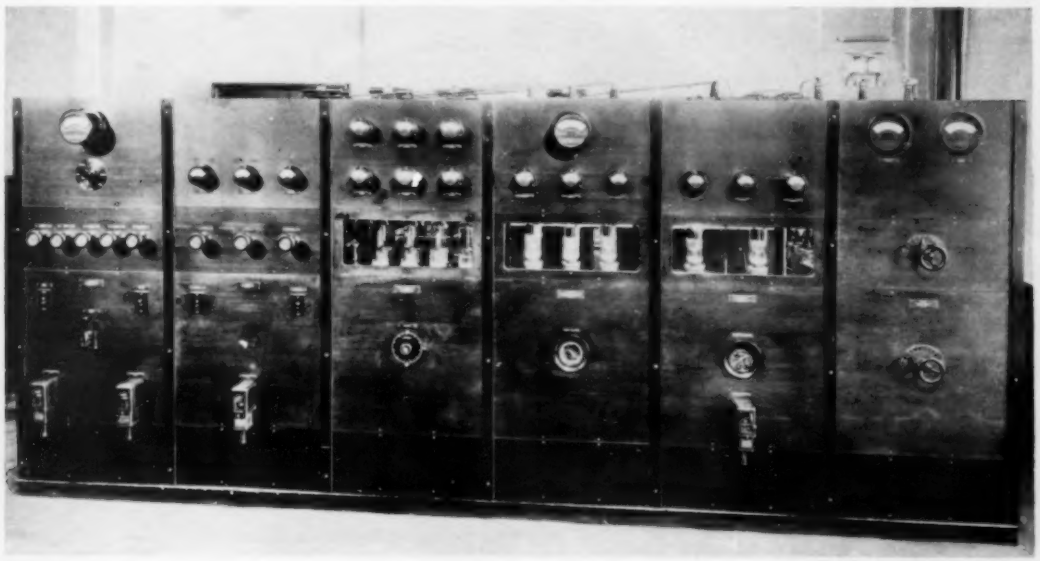


FIG. 6. ONE OF THE FIRST 5000 WATT, WATER-COOLED TRANSMITTERS USED IN STATION WEAF IN 1924.

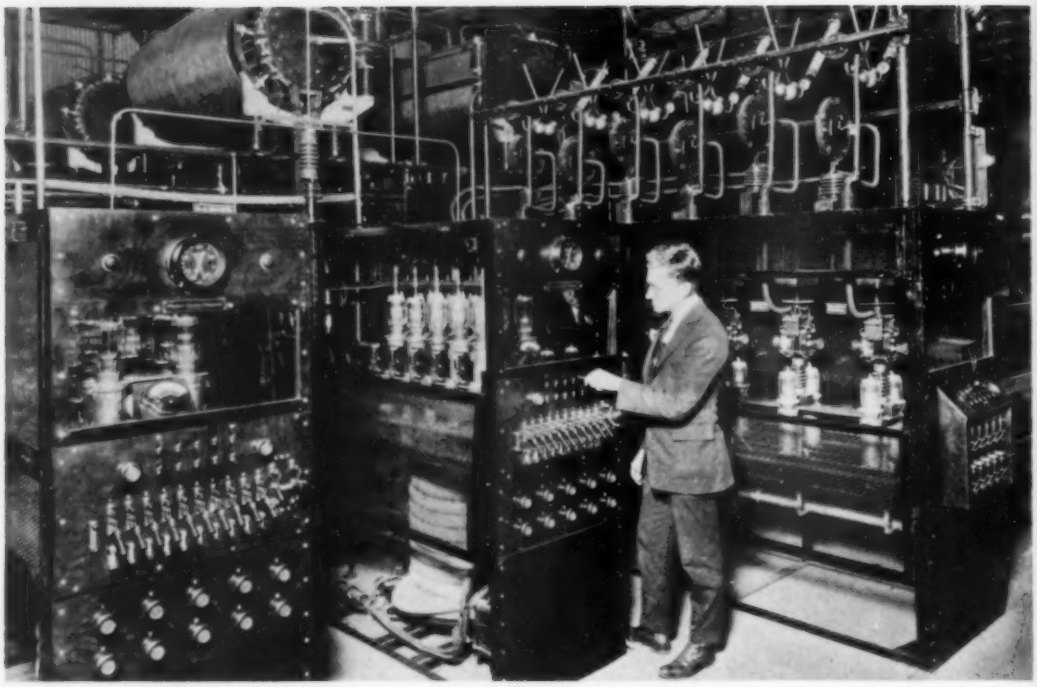


FIG. 7. POWERFUL WATER-COOLED RADIO TELEPHONE AMPLIFIER INSTALLED IN 1922 AT ROCKY POINT, L. I., FOR TRANSATLANTIC EXPERIMENTS WHICH CULMINATED IN COMMERCIAL SERVICE IN 1927.

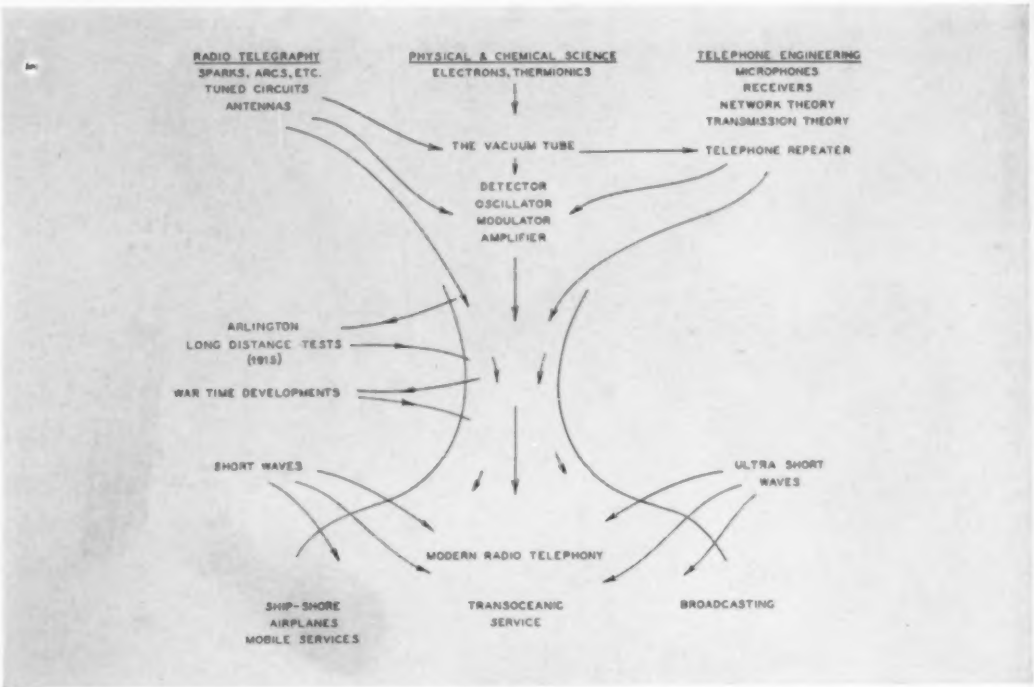


FIG. 8. A DIAGRAM OF THE FLOW OF THE ART OF RADIO TELEPHONY.

existed in the thousands of amateur radiotelegraphists spread throughout the country, a lively public interest in radiotelephony had been aroused during the war, and all that was needed to excite the public generally into providing itself with receiving apparatus was to have the experience of hearing speech and music on the air. These essential elements of an appropriate technique and of a widespread audience were lacking in the earlier years when De Forest and others broadcast speech and music upon a number of occasions with considerable success.

Public interest was first fanned by amateur listening to the experimental telephone transmissions being conducted by various people, amateur and professional. Engineers in making tests frequently availed themselves of reports written in by listeners, as a means of checking in a general way the effectiveness of their transmitters. For example, in the fall of 1919, tests made between New York and Cliffwood, New Jersey, of a pair of 500-watt transmitters intended for shipment to China, were reported by many amateur listeners. Tests of ship-to-shore radiotelephony, which were being made on more or less regular schedules from Deal Beach, New Jersey, were listened to and reported by hundreds of amateurs throughout the eastern part of the country. In the vicinity of Los Angeles listening to the radiotelephone link to Catalina Island was becoming enough of an indoor sport to be embarrassing to the public telephone service, as has been mentioned.

Of all the experimental activity at the time, it happened to fall to the personal efforts of Frank Conrad, an engineer of the Westinghouse Electric and Manufacturing Company, at Pittsburgh, to give rise to broadcasting of a continuing nature. Starting with transmissions from his home, the activity was taken up by his company, which had been engaged during the war in making radio apparatus for the government, and the experimental emissions were evolved into a continuing program, accompanied by the entering of the company into

the business of supplying receiving sets. The original transmitter of the now well-known station of KDKA is pictured in Figure 5 as it appeared on the occasion of its first broadcasting, when it sent out the returns of the presidential election on November 2, 1920. Note that the room which housed the transmitter served also as the studio. Public interest mounted rapidly and within a few years transmitting stations were growing up throughout the country and a boom was on in receiving sets. So great was the demand for transmitting station equipment that the telephone company was called upon to provide what proved to be most of the installations in these earlier days.

This great burst of activity brought with it real concern as to the character which broadcasting might assume and as to how it could be supported as a continuing service. As it was a form of telephony, the telephone company undertook to explore the field from the sending end by engaging in broadcast transmitting. There evolved the idea of putting the transmitter at the disposal of others for hire (toll broadcasting), the sponsored program, and arrangements for the syndication of programs over the wire telephone network. Thus was demonstrated the ability to support broadcasting from the sending end.

One of the first 5-kw, water-cooled transmitters, that was used in the telephone company's Station WEAF in 1924, is shown in Figure 6. Aside from representing an advanced design at the time, this transmitter is associated with an interesting bit of technical history. A 500-watt transmitter, which had been used just before it, had shown bad quality when received in certain outlying sections of the city on the far side of groups of skyscrapers. This gave rise to the making of one of the first studies of the broadcast transmission medium, including the element of fading and of coverage. The trouble proved to be due to the effect of the tall buildings in attenuating the direct transmission and making apparent interference between multiple paths. The effect of the interference upon quality proved

to be exaggerated by a degree of frequency modulation occurring in the transmitter. The latter trouble was removed by the adoption in the 5-kw transmitter of the master-oscillator type of circuit, employing piezo-electric crystal control, one of the first transmitters so provided.

The intimate technical relationship which existed between broadcasting and telephony in general is shown also in the high-quality side of broadcasting, involving studio acoustics, high-quality microphone pickup and high-quality amplifiers. In the beginning of broadcasting the pickup and amplifying means were taken more or less bodily from the high-quality speech-study work which had been going on in the telephone laboratories, and from public address systems. In 1919 a great public address demonstration had been made in New York upon the occasion of a Liberty Loan; and in the summer of 1920 such systems had played a prominent part in the two national political conventions. Addresses delivered over such systems from a distance emphasized the need for high-quality lines. As a result of such experience and the considerable amplifier-network technique which had been built up in the long-distance telephone field, it was possible at an early stage of broadcasting to adapt telephone lines to handle as wide a sound-frequency band as the economics of the situation justified.

Broadcast Receivers

A realization of the progress which has been made in broadcast receivers is had by contrasting the modern, stable and selective loudspeaker set with the ticklish crystal or regenerative battery set with which listeners first heard whispers in head-phones. One of the first advances was to the high-frequency amplifying set, whereby sensitivity was achieved together with simplicity of adjustment. The stabilizing of these sets against singing stimulated the art of tube-balancing circuits and is remembered by Hazeltine's neutrodyne. The superheterodyne, the indirectly-heated cathode tube permitting

operation from the a-c supply mains, the screen-grid tube, automatic gain control, featured the rapidly evolving receiving-set technique. Loudspeakers progressed from the old horn type to the armature-driven cone, to the electrodynamic, and multiple-unit system. While many of these advances had their origin elsewhere than in broadcasting, certainly the quantity production of broadcast receiving sets has been a powerful leaven in advancing the weak-current technique generally.

Transoceanic Telephony

As broadcasting was getting started, continuing research in the telephone laboratory gave promise of considerably greater transmitting powers, in the form of the copper-anode, water-cooled tube. This and the other advances which had occurred since the original transoceanic experiments of 1915 indicated that it might be timely again to undertake the problem of extending telephony overseas.

A powerful water-cooled amplifier, the first of its kind, was developed and in 1922, in cooperation with the Radio Corporation of America, was installed at the transatlantic transmitting station at Rocky Point, Long Island. It is pictured in Figure 7. Success attended the first objective of developing an antenna power of the order of 100 kilowatts and the transatlantic project was vigorously pushed. This work being in the then relatively low frequencies, it was possible to adopt single-sideband, carrier-suppressed transmission by borrowing that feature more or less bodily from the wire art, whereby the transmitting effectiveness was multiplied by a factor of about ten. The transmitting path to England was studied by making measurements there, in collaboration with the engineers of the British Post Office, of the diurnal and seasonal variations received and of the noise levels. A further improvement was obtained by borrowing from the wireless telegraph art the newly-developed directive antenna known as the Beverage wave antenna. There were, of course, other problems in get-

ting started, and these and the manner in which service was established, beginning in 1927, and, in time, extended by the use of high frequencies, are told in a companion paper entitled "Transoceanic Telephone Developments," by Ralph Bown.

Higher Frequencies and Mobile Services

The extension of radio to the higher frequencies, or shorter waves, gave new opportunity for the development of radio telephone services because of the greater message-carrying capacity of the higher frequencies and the greater transmission range.

Following the introduction of short waves to transatlantic telephony, the ship-to-shore problem was undertaken anew on a short-wave basis and service was initiated on the North Atlantic in 1929. On the shore end the essential facilities comprised a duplicate of one of the transatlantic point-to-point installations, including directive antennas pointing out along the transatlantic shipping route, and means for effecting two-way operation and for connecting into the wire network. The ship installation included a transmitter of 500 watts capacity, employing a new screen-grid power tube. As a result of "stay noise," there was adopted the "cut carrier" method of transmission. Most of the larger vessels are permanently equipped for service and marine telephone service is being given from both sides of the Atlantic.

A related form of marine telephone service is that to small boats. In the United States this started somewhat as a continuance by the Coast Guard of the submarine chaser installations of the war. In Europe fishing trawlers have been provided with simple radio telephone sets in considerable numbers. In these installations the intention has been to enable the boats to talk with each other and with certain land stations; not with the land line telephone users. Small-boat telephony linked with the land line network is a more difficult matter. It is now under active development in the United States on both the East

and West Coasts, and on the Great Lakes, and in some countries in Europe. The installations in the United States are of crystal-controlled sets, designed to be used directly by the officer of the ship without technical attendance. Many of the ships are equipped to be "rung" selectively as wanted by the shore station. The small-boat telephony works generally in the medium-frequency range of two to three megacycles.

Another type of mobile service is that being used throughout the airways of the United States in maintaining contact between the planes and the ground stations. Telephony has proven particularly useful here because of the facility it offers the pilots of communicating directly on a two-way basis with ground stations. The service is operated generally in the three to six megacycle portion of the spectrum. The apparatus is crystal-controlled, of special design for lightness, simplicity of operation and reliability. This type of service was well started about 1929.

A third type of mobile radiotelephone service, and one which has become quite important in the United States, is that of the various city and state police departments, used to direct patrol cars. Most of these services are limited to one-way talking to the cars, and operate on intermediate frequencies. Now that ultra-high frequencies are becoming available, some of these systems are being extended to two-way service. The apparatus is generally similar to that employed in the aviation service.

Ultra-High Frequencies

The recent extension of the radio technique to ultra-high frequencies brings new opportunities and also new problems for radiotelephony. One of the earliest practical trials of these frequencies for telephony, and one representing at the time a very large jump in frequency, was the 17-centimeter wave propagation across the English Channel in 1931, accomplished by the system developed by the laboratory of "Le Matériel

Téléphonique" of Paris, using the Barkhausen type of oscillator. Further experience has shown frequencies as high as this to be susceptible under some circumstances to rather serious transmission instability, resulting, it has been suggested, from changing moisture content of the air or from turbulent atmospheric conditions. A number of short radiotelephone links are now being operated in various parts of the world on somewhat lower frequencies, generally in the range of 40 to 100 megacycles.

It appears that as rapidly as the message-carrying capacity of radio is enlarged by extension to the ultra-high frequencies, the demand increases on the part of older services and of entirely new services, such as television. How much of the spectrum may be available for telephony will naturally be influenced by relative usefulness and economics. One problem is that of how to obtain radiotelephony sufficiently economically to "prove it in" for the shorter distances which characterize the useful range of these waves. Another is the one of preserving the privacy of communication by relatively simple means. It may be that the principle use of these waves for telephony will be for mobile services, thereby helping telephony keep pace with our increasingly mobile way of living.

Leaven of the Art

In describing the rise of radiotelephony we have spoken principally of physical things such as the vacuum tube, the filter circuit, etc. Another cross-section of the art would be the leaven of ideas which gave rise to it; the analyses and the reductions to measurement which enabled results to be obtained by design. That radiotelephony is particularly rich in this respect will be evident from the following citation of some of the more outstanding analytical contributions.

One of the first is that of van der Bijl's early study of the operation of the vacuum tube. In 1913–14 he derived approximate expressions for the plate current in terms of plate and grid

voltage, and presented the concept of the amplification factor μ. This work was published toward the end of the war and was the forerunner of his 1920 book on the vacuum tube, an authority for many years.

One of the earliest elucidations to be published of the operation of the audion as detector was the 1914 paper of Armstrong.

Next there is the more exact mathematical solution of the plate current in terms of the tube constants and grid voltage variation, given in an Institute paper in 1919; and the treatment of the vacuum tube as a part of a circuit network published the same year.

A potent factor has been the growing appreciation throughout the electric communication art generally of Fourier's theorem and the steady-state concept of transient phenomena. Related thereto is the band idea of wire telephone transmission which developed out of the frequency-band nature of speech itself, the characteristics of lines, and the necessity of suppressing reflections at circuit junctions. Campbell, using the loaded-line theory, combined the band idea of telephony with the sharp selectivity feature of radiotelegraphy to secure the wave-filter characteristic of a uniform transmission band, plus a sharp cutoff. This was a milestone in the development of circuit network theory.

Related to both vacuum tubes and the band conception were Carson's analysis of the modulated wave into the component carrier and sidebands and his invention of single-sideband transmission, made as far back as 1915, and the general extension of the side-band idea to high frequencies, which has meant so much to both wire carrier-current telephony and radiotelephony.

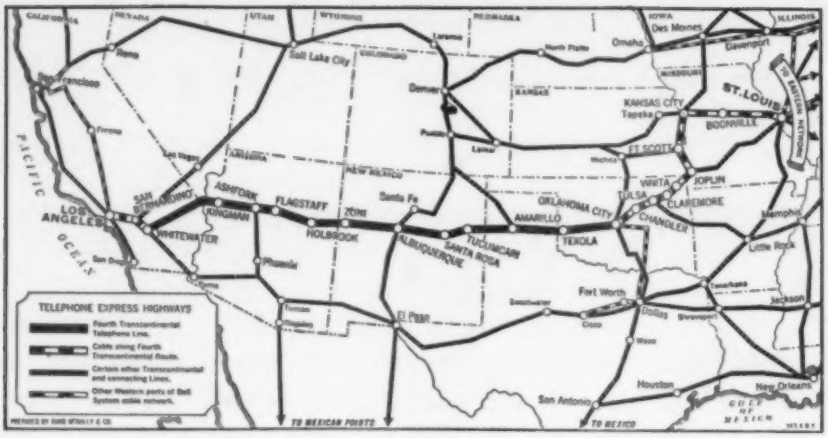
In the field of measurement and standardization there are the technique of making single-frequency measurements throughout a band, the decibel unit of attenuation, the volume indicator and the concept of volume range, and the measurements of the field strength of desired signals and of noise.

Figure 8 represents an attempt to diagram the flow of the art as a whole.

Future

Radiotelephony may be said to have "arrived" and to be still young. Looking toward the future, the writer likes to think of radio and wire telephony as increasingly dovetailing together to form one general front of advance. The principles and technical tools being fundamentally the same for both, a technical advance in one is likely to help the other. Thus radio has led the way to the higher frequencies and this has benefited wire communication, as we see in the carrier-current and wide-band coaxial cable development. As regards services, we observe that radio and wire telephony are one and the same thing in respect to the overall result, that of the delivery of sound messages. Where one or the other is to be used will be a matter of natural adaptability of the medium of transmission and of the economics of the situation, with the meeting line shifting from time to time, but with the main emphasis upon integration rather than differentiation. Thus does radiotelephony become an integral part of telephony and of the whole field of electric communications.

Lloyd Espenschied



Southwest Passage

"KNOW that on the right hand of the Indies," wrote the quaint Spanish writer Rodriguez de Montalvo "there is an island called California, very close to the side of the Terrestrial Paradise."

This was early in the Sixteenth Century. Subsequent explorations of his countrymen and others showed that he was off on his geography, and there are differences of opinion as to the proximity of California to the Terrestrial Paradise. But at all events, it soon became a Promised Land to great numbers from the East. Its gold, its climate, its commerce drew them as a magnet draws iron filings. They came seeking the fountain of youth and the well of gold, by way of the Horn and the covered wagon. Their nieces and nephews followed on the Iron Horse and through the ditch across Panama.

Born nearly three decades after the Forty-Niners had trekked westward, the telephone set out in pursuit of these lusty enthusiasts who had passed out of earshot. Pushing steadily across prairie, mountain and desert, it thrust its way through the Sierra Nevadas, reached the Golden Gate in 1915, in time for the celebration that marked the opening of the Panama Canal. "Hello Frisco" was not only a popular lyric, but an historic event in the development of communications.

For a year or so it threatened to remain an historic event, with a trickling traffic of two or three calls a day. But the East and the West had a lot to talk about. Timber from the forests of the Northwest was piling into the eastern lumber yards. Oregon orchardists were shipping their products eastward a good deal faster than an apple a day. Down in California, citrus fruits, teeming with unsuspected vitamins, were being packed eastward. Motion pictures had already reached the "colossal" stage. It was soon evident that more telephone lines were needed.

The first line to the Coast, now known as the Central Transcontinental, terminated at San Francisco, whence calls were switched to Oregon, Washington and Southern California. In 1923 a line was thrown across the southwestern corner of the country, thus providing a second line terminating at Los Angeles for service to the Coast. In the Northwest, lumber, apples, salmon and a busy route to the Orient gave the businessmen of Washington and Oregon a good deal to talk over with their eastern friends, and in 1927 the Northern Transcontinental was opened across Minnesota, North Dakota and Montana to Seattle.

These three highways of speech—Northern, Southern, and Central—give access to all parts of that teeming western shoreline, and by means of a system of lateral north-and-south lines, traffic can be diverted from one route to another, giving a flexibility highly advantageous in emergencies—storms or unprecedented peaks in traffic.

Hundreds of people now talk across the continent every day. And with the accretion of busy years, these three routes now provide more than one hundred telephone channels which cross the western states;—but they are not enough to meet the estimates of the not-so-distant future. So a few months ago surveyors went out, blue prints were unrolled and a new telephone express highway was evolved that followed in the shadow of

the transport planes across the great open spaces between Oklahoma City and Los Angeles.

The new "talkway," a straightening and widening of an older telephone route, is designed principally as a "through" way for long-haul traffic. In two notable respects it is well qualified for this important duty. In the first place, it will traverse a country rarely visited by the sleet storm, whose strangling coat of ice about the wires pulls the sturdiest poles to crazy angles. Second, it will employ a "carrier current" system of larger capacity, recently developed by the Bell Laboratories. By combining this new system with existing methods, it will be possible for *sixteen pairs of subscribers* to carry on, simultaneously over a single pair of wires, sixteen conversations as neatly and effectively separated from each other as the layers of a club sandwich.

The project is the largest construction job undertaken by the American Telephone and Telegraph Company since 1930. Briefly, it consists of a line of some 12,000 poles across a 290 mile stretch between Amarillo and Albuquerque, and the stringing of wires through these points from Oklahoma City to Whitewater, California;—thus providing a large capacity open wire line between the fine-mesh telephone network of the eastern half of the continent and the West Coast system. Several hundred men are employed in the work, the cost of which will exceed $2,000,000. The wire-stringing job will require some 3,500,000 pounds of copper, making up into 8,000 miles of wire. It is rough country, in spots. Between Amarillo and Albuquerque some five tons of dynamite have been used to blast out holes in which to set the telephone poles. At not infrequent intervals the line crosses rivers and creeks, and dry washes that at certain seasons are worse than several creeks and rivers put together. These must be crossed by a "catenary" or suspension construction for the crossarms, whose design often requires not a little ingenuity.

While Bell System engineers and linemen have run many lines across this kind of country, the preparations necessary in this case were on the scale of an expedition to the headwaters of the Amazon or into the less frequented regions of the Iranian plateau. The preliminary study, in the words of one of the field engineers, consisted in determining "the inaccessibility of the various routes." It meant breaking through a region that the hardy Spanish and American explorers had either avoided or penetrated with great difficulty and hardship.

In the making of the new route, A. T. and T. surveyors experienced two phenomena that are somewhat of a handicap to survey work. In the Panhandle they encountered rain. The special fact about this rain, in the words of one of the surveyors, was that "when it rains in the Panhandle it all falls at once."

Another thing that made survey work something less than a summer lark was the dust storm. According to one of the party, the Long Lines survey party, in the course of two and a half months, saw about eight days free from dust storms. They varied from a faintly perceptible haze to a murk that shut them in like fog. While these storms seldom lasted long, the party was generally too far out of town to quit work, and they worked on, in goggles and masks. And the dust was with them everywhere. Some of it was quite fine and had a choking biting odor. It filtered in through the windows at night, so that at first they slept with sheets over their heads and then in their masks. The dust even got into the tight joints of their transits and gave them a day's work cleaning them.

Another unpleasant manifestation of the dust storm was the static generated by the fast-moving particles. This was sufficient to give one a distinctly unpleasant shock, if one chanced to lean against a wire fence.

An unusual feature of the preparation for this undertaking was the survey of facilities that had to be made. Travelling from one end of the projected route to the other, the construc-

tion forces collected information about store-rooms, garages, machine shops, sidings, hospitals, boarding houses, restaurants, water and all the other facilities that are requisite in construction work. Operating in such rugged country, with long jumps between towns, information of this kind made it possible to work with a high degree of efficiency and economy.

The Fourth Transcontinental is being constructed so as to take advantage of the latest refinements in long distance telephony. Chief among these is the new type of high frequency "carrier current" system—the "J" type—that in the future will be used on it. This carrier, operating on frequencies ranging from 36,000 to 140,000 cycles, will provide twelve voice channels. It will operate on a pair of wires already carrying the regular voice telephone channel and a Type "C" carrier system, that gives three voiceways, using lower frequencies than the Type "J." Thus a total of sixteen circuits will ultimately be obtained from one pair of wires.

When the new carrier system is applied it will be necessary to increase the number of "repeater" stations along the route, and will greatly increase the problem of coordinating all the factors affecting the service on such long circuits. These repeaters are the vacuum tube amplifiers inserted at selected points along a telephone line to replenish the energy lost in transit. While these stations are generally spaced from 100 to 300 miles apart, depending upon the size of wire and other practical considerations, the distance will be cut materially on the Fourth Transcontinental when the "J" system is applied. Between Oklahoma City and Whitewater, a distance of about 1,200 miles, it is expected that a total of sixteen to eighteen repeater stations will be required on the new carrier channels. This is an average spacing of about 65 to 70 miles, compared with an average of some 240 on the existing type of open wire line along this route.

Another modification of equipment along this line is necessitated by the high frequencies to be used. Because of these,

the cross-arms are placed three feet apart, instead of the usual two feet, as a means of minimizing the "cross-talk" between adjacent pairs of wires. It is also necessary to have frequent "transposition" of each pair of wires, the wires crossing each other, in the case of some pairs, at every other pole. It recalls one of the first technical problems tackled by the American Telephone and Telegraph Co. Back in 1885 this phenomenon of cross-talk made its appearance on the newly constructed New York-Philadelphia line, one of the first metallic-circuit lines. The idea of transposition was hit upon and has since been a universal practice on long distance lines —though it has never before been necessary to cross the wires at such short intervals as in the case of the new carrier lines.

The Type "J" has introduced other refinements into the construction of the line. Poles must be spaced evenly, or very nearly so, on both existing and new sections of line—not always an easy task over such terrain—and the "sag" of the two wires of each pair must be uniform. To produce the desired accuracy, two systems of adjustment are employed. In the first, a wooden target, marked with equally spaced horizontal lines, is mounted on one pole; on the other, is a telescope, through which a lineman sights on the wires and gives orders—over the wire, to a man on the ground some distance beyond the other pole—to pull up or slack away. Incidentally, to be sure the adjustment is correct, the lineman must refer to a temperature chart which shows the varying sag at different temperatures.

In the second method each wire of the pair is plucked in such a way as to cause it to vibrate. The period of oscillation of each wire is compared with that of the other wire of the pair. If these periods are found to be alike, the wires have the same sag.

The Fourth Transcontinental is expected to prove a useful route, not only for telephone traffic, but for the many other communication facilities which the Bell System is called upon

to provide—circuits for broadcasting networks, for telegraph and teletypewriter service, and picture-transmission. It is expected that the line will be in commercial operation by the end of the year, although the twelve-channel carrier systems will not be provided until a later date.

Writing on the twentieth anniversary of transcontinental service (QUARTERLY, October 1935), J. J. Pilliod cites some interesting contrasts that are even more striking in relation to the new line. Speaking of the first circuit across the continent, he says: "Cable was avoided as far as was physically possible, because of the greater transmission loss which it introduced, and the eastern open wire terminal was brought to within three blocks of the Hudson River." The circuits of the Fourth Transcontinental will enter a cable at Oklahoma City, stretching Eastward approximately 1,600 miles to the Hudson River. Again, Mr. Pilliod points out that "no direct circuit from Chicago or New York to San Francisco was set up because the number of calls did not justify it." The new facilities of the Fourth Transcontinental will bring the total number of direct circuits from New York to San Francisco and Los Angeles up to 20, while from Chicago there will be nearly 30 direct circuits to West Coast cities. These are only a part of the voice channels to the western slope of the Sierra Nevadas. In addition, there are the coast-to-coast broadcasting network channels and scores of circuits for telegraph and teletypewriter services.

There are other evidences of notable technical advances. Back in 1915 the man in New York who wanted to call up his partner or his girl in San Francisco had to wait quite a while for the connection—probably half an hour or more. Today the average time to put through a long distance call, whether it's across a state line or across the continent, is less than two minutes. Technical improvement has also been reflected in another feature of great interest to everyone using the service,

Staking Out the Amarillo-Albuquerque Section of the Fourth Transcontinental Line on the Llano Estacado, or Staked Plains, So Called Ever Since Coronado Marked with Stakes the Path He Followed Over These Vast Spaces in 1542.

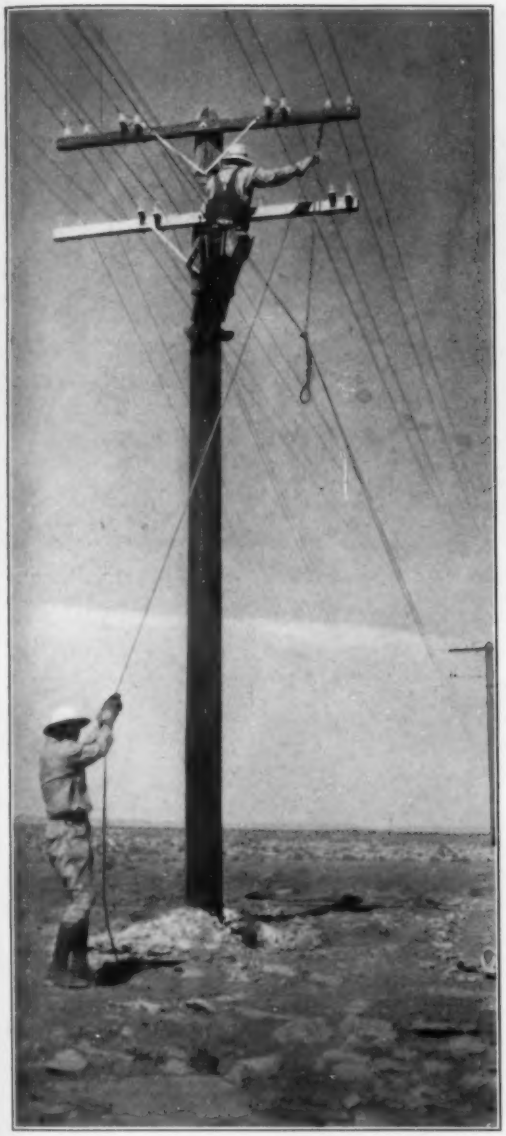
Pole Hole Digger Making Its Own Dust Storm in Good Going Between Moriarty and Santa Rosa, New Mexico.

Wound on "High Hats," the Wires Are Payed Out from a Motorized Hat Rack as the Linemen Advance Across Country through Cibola National Forest.

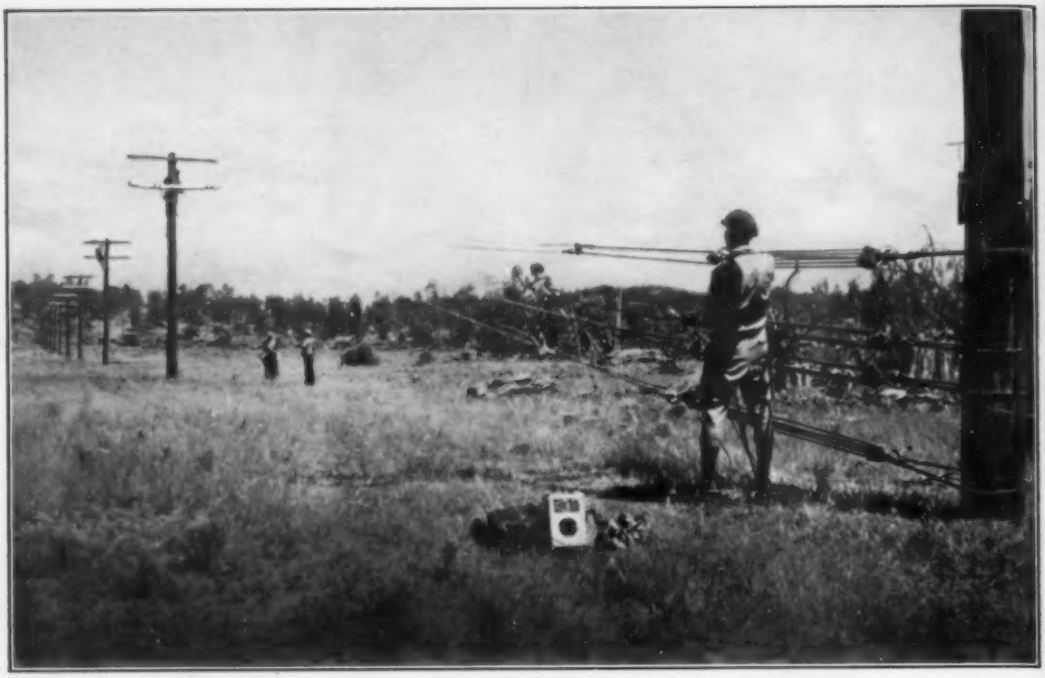
Dynamite for the Next Pole. It May Be Rock that Must Be Blasted Out or Mud or Sand, but the Pole Must Go In.

Survey Crews Were Equipped with Goggles and Masks Against Dust Storms Which Were an Almost Daily Occurrence.

Having Bored a Hole to the Proper Depth, the Telephone Truck Picks Up a Pole and Drops It into Proper Position.



HOISTING WIRES AT THE LEFT NEAR WINSLOW, ARIZ. SEPARATELY SPACED CIRCUITS AND MORE FREQUENT TRANSPOSITIONS ARE CHARACTERISTICS OF THIS LATEST CONSTRUCTION JOB. THE LINEMAN AT THE RIGHT IS PLUCKING THE TWO WIRES OF A PAIR TO START THEM DANCING. IF THEY KEEP STEP WITH EACH OTHER FOR A FEW SECONDS THEY HAVE SUBSTANTIALLY THE SAME "SAG"—A NECESSARY REFINEMENT FOR THE NEW CARRIER CURRENT SYSTEM.



THE WIRES HAVING BEEN STRUNG OVER A NEW CROSS-ARM, THEY ARE PULLED TAUT BY TACKLES. ALOFT ON THE POLES, LINEMEN CHECK THE SAG OF EACH PAIR AND SIGNAL ORDERS TO THE MAN ON THE GROUND.

PUTTING THE FINISHING TOUCHES ON A SECTION OF THE FOURTH TRANSCONTINENTAL LINE NEAR ASHFORK, ARIZONA.

namely the cost. It was almost the grand gesture of a prodigal to make a call in 1915, for a three-minute chat from New York to San Francisco cost $20.70. Today that same call, on a daytime station-to-station basis, costs $6.50. Or, if it be Sunday, or after the magic hour of 7 P.M. when the night rates go in, it would cost $4.25.

Another development of considerable importance has been the improvement in the quality of speech transmitted. In mathematical terms, the frequency band transmitted over the first transcontinental circuit was about 900 cycles. Today these circuits handle frequency bands ranging in width from 2,200 to 5,000 cycles. In perhaps more familiar terms, this means that the voice or music at the other end of the line, instead of sounding like those cylinders in the early phonographs, is not only recognizable, but pleasingly like the original.

Such an improvement has advantages too numerous to mention. It assists in the ready identification not only of voices, but of other sounds, and thus minimizes the risk of awkward moments. There is a story that shortly after the first transcontinental line was completed, General J. J. Carty determined upon a demonstration calculated to appeal to the imaginative mind. He was going to let the people listening at the San Francisco end hear the surf breaking on Rockaway Beach, near New York City. This new and magic wire would carry to the distant shores of the Pacific the sound which welcomed Henry Hudson as he entered New York Bay.

Since the effectiveness of such a demonstration depended in some measure on how smoothly it went off, General Carty arranged for a "dress rehearsal." The circuit was built up, all the way from New York to the Golden Gate. At each end of the line and at numerous intermediate points were skilled technical men, carefully testing each link in this chain.

At length all was in readiness. General Carty was at New York, an associate was in San Francisco. All the way across

the continent, pairs of ears listened carefully, intent upon maintaining the circuit. General Carty spoke to San Francisco. A moment later he "turned on" the roar of the surf at Rockaway.

The man at the Pittsburgh testboard started. He listened intently for a moment, threw a key and listened again. Then he cut in on the line: "That noise in the line," said he, "must be east of Pittsburgh."

GEORGE G. BREED

The International Radio Meeting of 1937

LATE last spring there was held at Bucharest, Rumania, an international conference on the subject of the technical regulation of radio. This was the fourth of a series of meetings held by the International Radio Consultative Committee (CCIR), an advisory body which originated at the Washington International Radio Conference of 1927. The object of these meetings is, in general, by international agreement to promote an orderly world use of the radio medium and minimize interference, and to prepare technical advice for subsequent more formal international administrative conferences, the next one of which is to meet in February, 1938, at Cairo, Egypt.

One of the principal subjects considered at these conferences is that of the constancy to which the frequency of a radio transmitting station should be held. At Bucharest the permissible variations were tightened up somewhat from those previously agreed upon. For example, for high-frequency (short wave) stations in the fixed services the permissible variations (tolerances) were recommended to be reduced from 0.02 per cent, the value given in the Madrid Regulations, to 0.01 per cent for new transmitters installed after 1938.

Another question upon which progress was made is that of indicating the limits of the harmonics of transmitting stations to which suppliers of equipment should work. A previous meeting of the CCIR, held at Lisbon, had recommended that for frequencies lower than 3 mc. a harmonic should not exceed 300 mv./m. at a distance of 5 km. from the transmitting antenna, equivalent to a harmonic power of about 0.25 watt in the antenna. The recommendation which was adopted at Bucharest applies to stations operating on frequencies above 3 mc., except for mobile stations, and requires any harmonic to be at least 40 db down as compared with the fundamental and

not to exceed in power 200 milliwatts. It was recognized that these limits will not insure against interference and that it remains an obligation on the part of the nations of the world to undertake special measures for suppressing harmonic interference where this becomes necessary.

A knowledge of the characteristics of wave propagation is, of course, fundamental to the planning of the use of radio channels. There were before the conference a number of treatises and curves on wave transmission. It became evident that the state of knowledge was as yet too incomplete to enable the subject to be presented in a comprehensive and yet simplified and practical form. It was left that the members of the subcommittee studying this question would continue their labors after the Bucharest meeting under the guidance of the administration which had centralized the subject, Great Britain, in an attempt to present it to the Cairo Conference in as useful form as possible.

On the subject of the field intensities which are necessary for the reception of various types of radio services, there was submitted to the conference a mass of data showing the field intensities actually being used, particularly in the United States. No conclusions were drawn and the subject was left upon the basis that further data of this kind, including noise levels, would be accumulated over the years and build up a picture of world-wide conditions as to received fields and noise levels.

One of the accomplishments of the Bucharest meeting was the classifying of the work of the CCIR along lines which will permit of the logical grouping of the recommendations of the committee and which can be followed to advantage in the setting up of subcommittees. The classification is as follows:

Organization and general matters.
Propagation of radio waves.
Transmitting station characteristics.
Receiving station characteristics.

Coordination, as between transmitter and receiver and as between different radio channels.

Standardization and measurements, involving terminology, definitions, measurements of fields, frequency, etc.

This classification is expected to help in better organizing the work of the CCIR. The more fundamental review of the field of competency of the CCIR and the further defining and planning of its work were left for the next administrative conference, that of Cairo.

A number of the twenty questions which were before the conference were found not to be subject to conclusions and were continued for further study. Some twenty new questions were proposed for the next meeting of this body. Several of these, which the United States was instrumental in getting adopted, are concerned with the important question of the band widths which are necessary for the various types of services and the minimum frequency separation which is practicable as between stations working on adjacent channels. These questions are, of course, fundamental to the more efficient use of the radio medium.

The United States Government was represented at this conference by a group of government department representatives, headed by Dr. J. H. Dellinger, of the Bureau of Standards. A number of the American operating companies were represented. For the Bell System there were present Messrs. C. O. Bickelhaupt, G. C. Barney, F. M. Ryan and L. Espenschied.

The Rumanian Administration was extremely kind in the arrangements made for the conference and for giving the delegates recreation and something of a picture of the remarkable country of Rumania. With the accretion of territory resulting from the War and the exploitation of oil, Rumania is developing rapidly. The activity and new buildings throughout the City of Bucharest were so striking as to present considerable of a "boom" appearance.

LLOYD ESPENSCHIED

Notes on Recent Occurrences

OPENING OF TELEPHONE SERVICE WITH HAITI EXTENDS CARIBBEAN SERVICE

HAITI, upon whose shores Columbus' flagship the *Santa Maria* came to grief on Christmas Eve, 1492, was brought within reach of Bell System telephones on September 29, 1937. Ceremonies inaugurating the new radiotelephone link included an exchange of greetings between Secretary of State Cordell Hull, speaking from Washington, and August Turnier, Acting Secretary of Foreign Relations for Haiti, who talked from Port au Prince.

Mr. Hull referred to the Republic of Haiti and the United States as the oldest independent countries in this hemisphere. "At the time of their independence, it required weeks to communicate from one capital to another but in recent years first the airplane and now the radio telephone have made possible immediate communication and are strengthening the historic bonds between us."

"The growing perfection of the means of international communication can only bring the peoples closer together," Mr. Turnier said. "And the Haitian Government rejoices that the Pan-American governments henceforth can count on still another factor in the service of their ideas of solidarity and of the development of their moral and material interests."

The service with the Caribbean republic is handled by means of a short wave circuit between radio stations of the American Telephone and Telegraph Company at Miami, Fla., and stations of the West Indian Telephone Company near Port au Prince. Thirteen Caribbean islands and adjacent countries are now reached by radiotelephone connections from Miami.

S. C. WILLIAMS ELECTED DIRECTOR OF AMERICAN TELEPHONE AND TELEGRAPH COMPANY

AT a meeting of the Board of Directors of the American Telephone and Telegraph Company held on July 21, S. Clay Williams, of Winston Salem, N. C., was elected a director to fill the vacancy caused by the death of George F. Baker. Mr. Williams is Chairman of the Board of the R. J. Reynolds Tobacco Company.